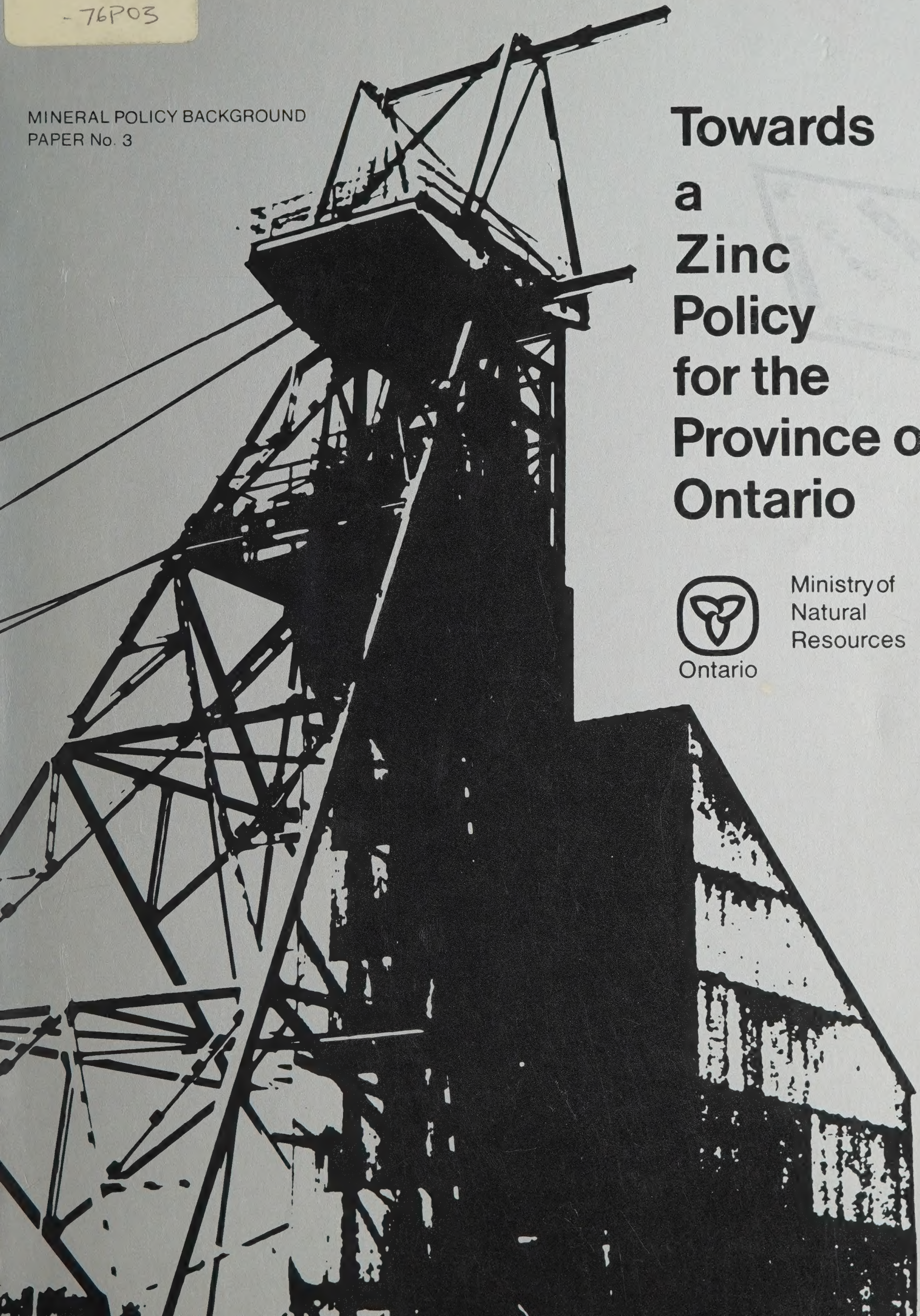
MINERAL POLICY BACKGROUND
PAPER No. 3



Towards a Zinc Policy for the Province of Ontario

Ministry of Natural Resources
Ontario

The Authors

K.S. RACHAMALLA, *M.B.A., M.Eng., P.Eng.,*
Financial Advisor and Mining Engineer, is a Policy Analyst with the Mineral Resources Branch, Ontario Ministry of Natural Resources, Toronto.

D.H. BELL, *Ph.D., P.Eng.,*
Metallurgical Engineer, is a Policy Analyst with the Mineral Resources Branch, Ontario Ministry of Natural Resources, Toronto.

NOTE:
This background paper does not represent official policy of the Government of Ontario.

Opinions expressed in this paper are those of the authors and do not necessarily reflect government policy.

Data used or reproduced are the best available at the time of writing. As the data base improves, the implications of the papers in this series are constantly re-evaluated.

December, 1976

Price: $12.00

Towards a Zinc Policy for the Province of Ontario

MINERAL POLICY BACKGROUND PAPER NO. 3

K. S. RACHAMALLA
D. H. BELL

Metallic Minerals Section
Mineral Resources Branch
Division of Mines

Ontario

Ministry of Natural Resources

Hon. Leo Bernier
Minister

Dr. J. K. Reynolds
Deputy Minister

Rachamalla, K.S., Bell, D.H.,
1976: Towards a Zinc Policy for the Province of Ontario; Ontario Ministry of Natural Resources, Division of Mines, Mineral Policy Background Paper No. 3. 5509 (11/76)

Table of Contents

Table of Contents (Continued)

List of Figures

List of Tables

List of Tables (Continued)

NOTE OF EXPLANATION: METRIC CONVERSION

Much of the data contained in this report is in converted metric units as recommended by the Ontario Interministerial Committee on National Standards and Specifications (Metric Committee). The tonne, commonly called metric ton (1 t=1000 kg), is used throughout the text unless otherwise noted. Recommended conversion is 1 ton (short; 2000 lb) = 907.184 74 kg and 1 ton (long; 2240 lb) = 1016.046 908 8 kg.

Foreword

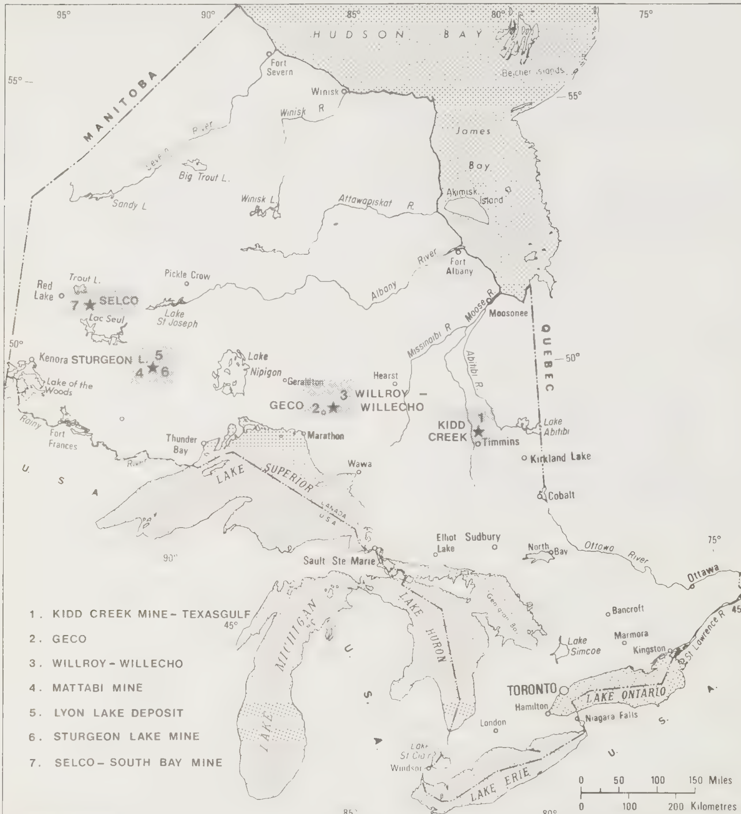
The report "Towards a Zinc Policy for the Province of Ontario" is the third in a series of studies prepared by the staff of the Metallic Minerals Section, Division of Mines, Ministry of Natural Resources. The series has grown out of the recognition that each of the major metal commodities produced in Ontario is a unique entity with unique characteristics in a world-wide market.

If government policies are to be formulated effectively, a thorough, in-depth understanding of the relationships between the Ontario industry and the world market on the one hand, and between the Ontario government and the Ontario industry on the other, is of vital importance.

This report is an attempt to outline Ontario's role in a world-wide perspective and to achieve the required understanding that will aid in the formulation of a zinc policy for this province.

The study provides background information about the zinc industry, as a basis for Ontario's policy formulation. Contained in the study are not only statistical data, price and stock behaviour and a review of the structure of the zinc industry, but also the authors' interpretations and analyses of this information in terms of Ontario's zinc policy options.

ZINC MINES OF ONTARIO



Chapter 1

The Zinc Industry of Ontario

Policy Proposal

The Problem

THE ISSUES

Three-quarters of Ontario's mined zinc production left the province as concentrates in 1975. The remaining 25% of the province's concentrates were processed to slab zinc by Texasgulf Canada Ltd., Ontario's only zinc metal producer, which came on-stream in late 1972. Out of Ontario's total estimated mine production of 374 000 tonnes of zinc in concentrate in 1975, an estimated 15% was processed to refined metal in Quebec, and about 60% was exported out of Canada as concentrates.

Ontario's inventory of known, undeveloped zinc resources is not adequate to maintain its present zinc production status in the world through the year 2000.

A detailed study of the provincial inventory of zinc reserves and resources is underway. However, the information obtained will not be released due to the confidential nature of the data.

Ontario produces between 28% and 35% of Canada's mined zinc. It is the leading zinc producing province in Canada and ranks with the world's major zinc concentrate producers, such as the United States, Australia, and Peru, which ranked third, fourth, and fifth, behind Russia, the world's second largest zinc producer (see Figure I). Canada is the world's largest producer of mined zinc, with an output of 1 195 000 tonnes of contained zinc in 1975.

It may be argued on the basis of current published ore reserve data, that four of Ontario's six producing mines (Mattabi, Willroy, Selco and Sturgeon Lake) will likely be closed down by 1985 or earlier. Current published ore reserve data indicate that zinc production from Texasgulf and Geco, two of Ontario's major producers, could be exhausted by the year 2000.

THE OBJECTIVE

The Government of Ontario is committed to the objective of securing for the people of Ontario the maximum economic benefit from Ontario's mineral resources in terms of jobs and income through the investment of private capital.

The aims of the province's zinc policy are derived mainly from the following broad policy objectives outlined in **Towards a Mineral Policy for Canada**:
a) "strengthen the contribution of minerals to regional development";
b) "realize opportunities for further mineral processing";
c) "increase the return to Canadians from exportable mineral surpluses";
d) "improve mineral conservation and use".

The province's mineral policy thrust should be directed towards:
i) maintaining Ontario's status in mined zinc production through the encouragement of private-sector investment in exploration and mine development; and
ii) increasing the level of refined zinc production in Ontario by enhancing the investment climate for zinc refining capacity in Ontario.

THE URGENCY

Since the start-up of Texasgulf's zinc refinery in 1972, about 40% of the zinc from Ontario's mines has been processed to refined metal in Canada.

Ontario's objective of processing its mined output to the prime metal stage in Canada has been largely achieved in the case of copper, and to a lesser extent in the case of nickel. Zinc remains a notable exception.

About 92 percent of all copper from Ontario's mines is processed to refined metal in Canada.

About 62 percent of all nickel from Ontario's mines is processed to refined metal in Canada.

The Provincial Government's major means to induce the construction of zinc refining facilities in Ontario are the incentives to mine producers incorporated into The Mining Tax Act (April 9, 1974). The suspension of the disallowance of foreign processing costs until 1979, is only a temporary relief from what is essentially a disincentive to foreign processing, rather than a positive incentive to domestic processing.

Although the zinc mine production of Ontario is in excess of the requirements of existing refining capacity, there is at present no mechanism to encourage the construction of independent toll refining facilities in Ontario.

In the past the major zinc consuming countries – such as Belgium, Germany, Japan and the U.S. – were the beneficiaries of the establishment of their own domestic zinc refining industries. The present and future zinc refining facilities will likely be built in countries which produce abundant quantities of zinc concentrates.

If the plants are not planned now and built here in Ontario they will likely be built elsewhere.

In order to maintain Ontario's current status on the world zinc scene (let alone growth), formidable exploration efforts are needed. The time-lag between discovery and production is 5–10 years. *Therefore enhancement of exploration investment must be regarded as a high-priority objective.*

THE PROBLEM WITH RESPECT TO ESTABLISHED POLICIES AND PRIORITIES

The provincial zinc policy goals are to encourage private sector exploration and to promote further processing. There are numerous interrelated factors which hinder the accomplishment of these goals. Complexities arise from environmental and energy concerns, as well as differing inter-provincial, provincial-federal and government-industry objectives.

The Ontario Mining Tax Act and The Mining Act are presently designed to foster further processing, offering carrots and sticks, respectively. For the legislation to be effective, other provincial policies regarding energy availability, labour supply, infrastructure and environmental protection must be structured to complement the goals rather than conflict with them. Long-term stability in mineral taxation legislation – both federal and provincial – is required to facilitate the planning and financing of exploration and new mining projects.

Zinc refining is a capital intensive industry, as well as a heavy consumer of electrical energy. The unit cost of a zinc refining facility is currently estimated to be in excess of \$1 500 per tonne of annual capacity. Thus, a plant with 100 000 tonnes annual capacity would require a total capital investment in excess of \$150 million.

The energy consumption is about 4 000 kWh per tonne of zinc metal produced. A refinery of 100 000 tonnes per year capacity has a power demand of about 50 000 kilowatts. If the province wishes to pursue a policy of attracting metal-extracting industries to Northern Ontario, then the power rates must be competitive with the rates in other provinces. At present, the electrical power to accommodate a new zinc refinery is not available in Northern Ontario.

The zinc mining, milling and refining industry in Ontario provides direct employment for some 3 000 people. The mining industry of Northern Ontario suffers not only from a persistent labour shortage but also from a high labour turn-over. A zinc refinery of 100 000 tonnes per year would create about 400 additional jobs, which means that housing and infrastructure facilities for about 2 000 people would be required. To attract and retain the required labour-force, government policies must aim at alleviating the problem of labour shortage and countering the contrary effects of federal and provincial policies in other areas which have a high income transfer component, such as health, welfare, education and immigration.

The lack of an adequate amount of serviced land at reasonable cost is a major problem in the development of new projects. The supply of serviced lots is inhibited by present land-use planning policies which attempt to provide urban southern Ontario standards to remote Northern Ontario developments. New ideas in land assembly and development are required, for example, a new look at the "company town" concept may be worthwhile.

The present provincial environmental protection and regional planning legislation is resulting in serious delays in project completions. Delays in start-up of projects cause loss of production and significantly increase the capital cost through increased interest charges. These are in addition to the direct capital and operating costs and the costs of pollution control installations.

The mining industry has lost its long-standing federal incentives for mineral exploration and exploitation. In addition, the federal government has not maintained a stable tax environment since the tax reform in 1972. Budgetary changes in 1974 and 1975 have led to a high level of uncertainty in the mining industry. *Mineral policies, both federal and provincial, should be stable over the long-term and should not be subjected to year-to-year budgetary modifications, if investment in exploration and development is to be maintained at its present level, let alone increased.*

Trade barriers, both tariff and non-tariff, represent an important constraint to the export of refined zinc metal from Canada, and hence a constraint to increased zinc metal production in Canada.

In forumlating policy for Ontario's mining industry, a wide variety of perplexing problems must be dealt with. Some of the questions arising from this study of Ontario's zinc industry are:
- does Ontario want to compete with the rest of the world for slab zinc capacity?
- should Ontario support a policy of encouraging full processing at the national level or at the provincial level?
- can (and will) Ontario make power available in North-Western Ontario at competitive rates?
- can vertical integration – e.g. from mining through to die-casting – be achieved in Ontario?
- does Ontario want to support the Canadian federal position of using concentrate supply as a bargaining "chip" at the GATT negotiations?
- should Ontario support the Canadian federal stance of encouraging the full processing of appropriate ore bodies, for example the zinc deposits of New Brunswick?

Alternatives

When a policy's costs and benefits are compared, or when policy options are compared, two thoughts must remain foremost. One is that the policy choice will affect investment decisions involving literally hundreds of millions of dollars; the other is that if the investment decisions are made in the private sector, they will be made in favour of the location promising the highest expected after-tax rate of return.

A healthy mineral sector is the goal of Ontario's mineral policies. However, investing government funds in exploration will not achieve that goal. Orebodies are similar to other capital goods, and their discovery (or production) responds to market forces. The lack of demand for ore-bodies in Ontario stems from the non-competitive after-tax rate of return expected from the capital required to bring a discovery into production.

Policy options with respect to the Ontario zinc industry may be considered under the following three headings:

1. *ENCOURAGE EXPLORATION IN ONTARIO:*
   by providing additional tax incentives to private industry, for example an exploration mining tax credit. This tax credit could be given either every year, or in the years of low profitability (when the companies' processing allowances are determined on the basis of 65% of combined profit);

The provincial incentives may be inadequate to have the desired impact, unless the federal tax incentives are made equally attractive.

2. *IMPROVE THE LEVEL OF REFINED ZINC PRODUCTION IN ONTARIO*

The construction of zinc refining facilities in Ontario can be accomplished only if the current production of mined zinc and the ore reserve base are enlarged or at least maintained to the year 2000. The encouragement of the construction of new capacity could be provided by:

a) additional positive incentives such as:
   i) infrastructure facilities;
   ii) measures to provide adequate electric power at competitive rates, vis a vis the other provinces;
   iii) measures to increase the supply of labour;
   iv) increasing the processing allowances under The Mining Tax Act for a zinc refinery in Northern Ontario (e.g. to 40%–50%).
b) direct provincial involvement in a custom refinery, e.g. Crown Corporation or joint-venture.

3. DO NOTHING

Unless exploration continues and new discoveries of zinc are found, Ontario's zinc concentrate production will dwindle and its world status will be lost in a 15-20 year period. Should no new zinc mines be found and brought on stream, Ontario's annual zinc output could drop to the production level of the early 1960's, i.e. about 50 000 tonnes per annum by the year 2000. Zinc producers such as Mattabi will be phased out while Texasgulf will undergo a transition from predominantly a zinc mine to a copper mine.

Texasgulf's mined zinc output from the Kidd Creek mine is projected to fall as the mine increases in depth. Their mined zinc production will have decreased by 1990, so that the refinery will be able to treat 75% to 100% of the zinc concentrates produced, even though the zinc refining capacity will remain at the 1975 level. Under these conditions, Ontario will be processing about 50% to 75% of its total mined zinc production as a result of the lower level of output.

There are a number of obstacles in the way of increasing the zinc refining capacity in Northern Ontario. These include:
- power is presently not available
- Ontario's present power rates are high relative to those of other provinces'
- skilled labour is in short supply in Northern Ontario
- concentrate availability from Ontario is not assured, and it might have to be supplied from other provinces or territories.
- a zinc plant has a high capital requirement.

In view of these problems it is unlikely that additional zinc refinery capacity would be built in Ontario, unless concerted government efforts were exerted to solve these problems.

Background Information

Zinc Uses: Zinc is consumed in large quantities in four widely divergent applications. Its uses are in the form of castings and rolled zinc, galvanizing, brass and zinc oxide. Die-casting is closely related to the production of hard goods, such as automobiles, electrical appliances and hardware. Galvanizing is used to protect steel against rust in uses such as construction, motor vehicles, fencing and hardware. As a chemical, zinc is used in vulcanizing rubber, photocopying, pharmaceuticals and paint pigments.

Production Source: The great majority of the world's zinc is extracted from sulphide ores by the electrolytic process which produces very pure metallic zinc. Zinc oxide is produced directly from zinc ore and concentrates or from zinc metal. Unlike nickel, zinc is not found in commercial quantities in the seabed nodules, and therefore does not face the potential competition from the development of ocean nodular resources.

Zinc History: Zinc was used as far back as Roman times as an alloying material in brass, but was not recognized as the metal. Zinc appears to have been known in India as early as 1000 to 1300 A.D. Its physical properties were described by Paracelsus in the early 16th century. About 1730, the technology of smelting of "spelter" (the commercial name for slab zinc) was brought from China to England, and by 1739 a smelter of about 200 tonnes per year capacity had been erected at Bristol.

Zinc was first smelted in the U.S. in 1835 and commercial production began in 1860.

In Canada, zinc mining started in 1898 but was on a small scale until 1916. By 1923, Cominco's Kimberley mine in B.C. commenced large-scale production. Canadian zinc output has increased continuously since that time and at present Canada is the world's leading producer of mined zinc.

Zinc Mineralogy: Zinc-bearing ore minerals are generally found in a variety of polymetallic ores. It is found not only as a predominantly zinc ore, but also as lead-zinc ore, as copper-zinc ore and as lead-copper-zinc ore. As a further complication to the relationship, these ores frequently contain important quantities of silver and cadmium, as well as lesser amounts of tin, bismuth, thallium, indium and germanium. A zinc-bearing deposit which may not be economically viable on the basis of zinc alone, may be exploitable on the strength of the associated metal values in the ore.

THE FUTURE FOR WORLD ZINC

Over the next two to three decades, the world demand for zinc is projected to grow dramatically, and meeting this growth will present a formidable challenge to the zinc mining and refining industry. If the historical 5% annual growth rate of consumption, which has prevailed since 1960, is assumed to continue, world consumption of slab zinc will exceed 15.5 million tonnes annually by the end of this century. It can be argued that the 5% growth rate is unrealistically high and that in the future, fewer cars will be built (one third of U.S. zinc consumption is in the automobile industry), and less steel will be galvanized. Over the 1970-74 period, the rate of growth of zinc demand has been 4%, but whether the annual rate is 2% (7.5 million tonnes per year by 2000 A.D.) or 3% (9.5 million tonnes) or 4% (12 million tonnes) the conclusion is the same: zinc producers will be hard pressed to supply growing demand. Many zinc mines and smelter-refinery complexes will have to be built.

Putting this long term forecast into short term perspective, a modest growth in consumption of 2.5%–3.5% will necessitate an additional 200 000–300 000 tonnes of refined zinc production capacity *each year.* This will require the output of 4-6 mines of significant size, *annually.* In addition, the depleted mines and obsolete smelters will have to be replaced.

The zinc industry faces many problems in bringing new capacity on-stream. Mineral exploration and development are high risk endeavours. Zinc refining is a capital and energy intensive business. World-wide inflation, government restrictions on prices and strict environmental standards seriously interfere with attaining a healthy level of profitability. In particular, *the planning and financing of new mines and refineries require a stable tax environment, free of political uncertainty.*

ONTARIO ZINC CONCENTRATE

Ontario is fairly new in the world of zinc concentrate production; significant output commenced in 1958 and world status was achieved in 1968. Ontario's 1975 production of 374 000 tonnes of zinc in concentrate represented 8% of total Free World mine production. Leading mine producers of zinc are: Canada (29% of Free World production), the United States (10.9%), Australia (10.3%), Peru (9.3%), Mexico (6.3%) and Japan (5.8%). These six countries together supply approximately three-quarters of the total Free World mined zinc output.

ONTARIO SLAB ZINC

Ontario produced about 20% of Canada's or 2½% of the Free World's slab zinc output in 1975. Texasgulf's zinc plant, the only zinc refining complex in Ontario, produced 84 000 tonnes of slab zinc in 1975. In addition, 15% of Ontario's production was refined in other provinces; thus a total of 40% of Ontario's mined zinc output was refined in Canada. The major slab zinc producing countries include the United States (13% of Free World slab zinc production in 1974), Canada (10%), Japan (20%), West Germany (9%), total Western Europe (40%), and Australia (6%).

FREE WORLD ZINC CONSUMPTION

Consumption of slab zinc is concentrated in three major blocks, the United States, Japan and Europe. These three together accounted for 78% of Free World metal consumption in 1975. Galvanizing, die-casting and brass are the three major consuming end-use sectors. The primary zinc industry does not face the competition of a large secondary (scrap) sector, as does the primary lead industry.

ZINC CONCENTRATE PRODUCERS

The leading exporting countries of zinc concentrate are Canada, Australia, Peru and Mexico. The markets for zinc concentrate – namely Europe, Japan and (in the past) the United States – are well established from the viewpoint of metal production and consumption. Traditionally, the consuming nations have encouraged the establishment of

their domestic refining facilities by means of both tariff and non-tariff trade barriers. These were designed to promote imports of zinc concentrate while discouraging imports of metal. Major benefits believed to flow from these policies include:

- the protection of the domestic zinc consuming industries (i.e. secondary manufacturing) by providing security of supply of refined zinc metal;
- creation of direct and indirect domestic employment opportunities with the establishment of facilities for processing to the prime metal stage and beyond;
- importation of zinc with a minimum value-added content, resulting in balance of payments advantages;
- importation of sulphur and other minor elements **at no cost**.

The U.S.S.R. is the world's second largest producer of mined zinc, with a reported 1974 output of 950 000 tonnes. Statistical information for the communist countries is sporadic and incomplete, however, available data indicate that Russia is a net importer of zinc concentrates, mainly from other Eastern Block countries.

SLAB ZINC PRODUCERS

European Zinc Refiners: European zinc refiners have been well established for many years and operate modern up-to-date refineries. In some cases they are vertically integrated back to concentrate production in other countries. The EEC, which is the world's largest consumer of zinc, produces only 47% of its zinc concentrate requirement from domestic mining sources.

Japan: Japan is only 31% self-sufficient in its zinc concentrate requirement. However, its consumption makes it one of the three major competitors for zinc concentrates in the Free World. The Japanese zinc industry is relatively young and has developed aggressive marketers and consumers, and its refining complexes are among the leaders in innovative process technology.

Russia: Russian slab zinc production in 1974 was 980 000 tonnes. This represented a 72% increase over the 1970 production of 570 000 tonnes. Although Russia exported only 41 000 tonnes of slab zinc to western countries in 1974, its slab zinc exports to all countries totalled 117 000 tonnes.

The EEC and Japan: Both the EEC and Japan have succeeded in developing self-sufficiency in zinc refining capacity, while the United States lost its self-sufficient position in the domestic development of refined zinc capacity.

The United States: The U.S. domestic supply of zinc concentrates has declined over the past decade (from 554 000 tonnes per year in 1965 to about 430 000 tonnes per year in 1975), and has not provided the assured source of feed required for the expansion of domestic zinc refining capacity.

Until 1975, the U.S. was the only country to impose an import duty on zinc in concentrates while its competitors, the EEC and Japan imported concentrates on a duty free basis and restricted the import of zinc metal. The mineral-rich countries are adopting policies to encourage the growth of their domestic smelting-refining facilities. This trend is most evident in such major zinc-exporting countries as Canada, Australia, Peru and Mexico.

The United States lost 55% of its production capacity between 1969 and 1975. A combination of economic and environmental factors resulted in the closure of ten plants accounting for 690 000 tonnes of slab zinc capacity annually. At present several new refineries are being planned. The New Jersey Zinc Company and Union Miniere SA of Belgium have formed a joint venture to bring a 81 600 tonne per year refinery into production at Clarksville, Tennessee in 1979. This represents the first additional new zinc refining capacity built in the U.S. since 1941. The National Zinc Company will start up its new electrolytic zinc plant at Bartlesville, Oklahoma in mid-1976; this plant will replace the company's obsolete horizontal retort facility which is being phased out of production during 1976. Asarco and MIM Holdings of Australia have agreed to participate as co-venturers in Asarco's proposed 163 000 tonnes per year Stephensport, Kentucky refinery, however, financing and concentrate supply for the project have not yet been arranged, nor has the supply of power.

High capital costs and high construction and operating costs were a deterrent to new zinc plant construction in the U.S. Costs in Europe had been about one-half, and in Japan about one-third, of those in the U.S. These differences were partially due to currency fluctuations, different anti-pollution laws, and differences in the labour component in construction.

It should be noted, however, that there are recent signs of a reversal as European interests have started to establish manufacturing plants in the U.S. on the grounds that labour costs there are lower than in Europe.

ZINC STOCKS

U.S. Stockpile: The huge U.S. government stockpile of over 1 million tonnes of zinc, prior to 1972, was a major stumbling block to the expansion of U.S. zinc refining capacity. The stockpile objective, until June 28, 1976, was 183 886 tonnes, and 156 154 tonnes of zinc were to be released under authorization for disposal. On June 28, 1976, the Federal Preparedness Agency (FPA) announced an increase in the official objective to 340 040 tonnes of zinc, equal to the entire quantity held in the strategic stockpile at that time.

On October 1, 1976 the FPA announced new stockpile objectives for 93 critical and strategic materials. The objective for zinc was raised from 340 040 tonnes to 1.19 million tonnes. Funds to buy materials for the stockpile must be appropriated by Congress, and the FPA did not foresee acquisition beginning before October 1977. Authorization for sale from the stockpile is at the discretion of Congress.

Producer and Consumer Stocks: Both producers' and consumers' zinc stocks increased to very high levels in mid-1975 as the economic recession of 1974-1975 took hold. A combination of production cut-backs and the present slow recovery in consumption is expected to bring the stocks down to acceptable levels by the end of 1976 or early 1977. The effects of lower production and the absence of GSA sales were partially nullified by market pressures due to large imports into the U.S. of foreign zinc metal.

ZINC TRADING

Zinc is an international commodity. At present the major consuming blocks, the U.S., the EEC, and Japan are essentially "HAVE-NOT" nations with respect to developed zinc mineral resources. This results in a large international trade in zinc concentrates and refined metal.

In Ontario, two companies, Noranda and Texasgulf, are involved in the production and marketing of zinc concentrate, to the extent of 95% of Ontario's total zinc concentrate production.

The major customers for Ontario's exported zinc concentrates are: the U.S., which receives concentrates from Texasgulf, Willroy, Selco and Mattabi, and Japan, which receives concentrates from Texasgulf. The output from Texasgulf, Selco, Sturgeon Lake and Mattabi are also marketed to Europe and other countries. Detailed information pertaining to country of destination and tonnages of concentrate shipped is not available.

The slab zinc from Texasgulf's Hoyle refinery at Timmins, Ontario, is marketed through the company's metal sales organization in Toronto. The marketing organization for Noranda's output is Noranda Sales Corporation Limited, in Toronto.

World zinc metal prices are partly influenced by the zinc concentrate suppliers of Canada, but only while they retain control of the supply and marketing of the concentrate and maintain an appropriate balance between concentrate and metal production. Should metal production grow out of balance with concentrate production, then the influence over the price (provided by significant volume in concentrate marketing) would be lost.

The control by only a few companies of Canadian zinc concentrate production and marketing is exercised through a combination of direct and indirect equity holdings and sales arrangements. Canadian zinc concentrate production and marketing is strongly influenced by the firms: Noranda (30%–35% of total Canadian zinc production), Cominco (20%–25%), Texasgulf (20%–22%), Cyprus-Anvil (8%–10%), and Hudson Bay Mining and Smelting (3%–4%). With the exception of Cyprus-Anvil, the other four companies also control 100% of zinc metal production in Canada.

Canadian zinc is sold at different prices in different markets. It is sold at the Canadian Producers' price in Canada, largely at the U.S. Producers' price in the U.S. and at the non-North American (European) Producers' price in the rest of the world. Only small amounts of zinc are traded at the London Metal Exchange (LME) price.

In August, 1976, the Canadian Producers' price was increased to 39¢ per pound. The U.S. Producer price increased from 37¢ to 40¢ per pound in August, 1976. In October, 1976, the Canadian and the U.S. Producer prices for P.W. zinc were rolled back to 37¢ per pound. The European Producers' price rose from £360/tonne to £390/tonne (equivalent

to 32¢ per pound and 36¢ per pound, respectively) in 1975; in the same period the LME price ranged between £321.9/tonne and £348.4/tonne. The LME spot price, as of November 14, 1976, was £370/tonne, or 27¢/lb. Changes in the price of zinc have been largely due to currency fluctuations, and in particular to the devaluations of the pound during 1975. In January, 1976, the European Producer price quotation changed from £/tonne to $/tonne.

Marketing of zinc concentrates is largely done through a contract between the concentrate producer and the refiner for the toll refining of the concentrate. In toll refining the concentrate producer retains title to the zinc, and pays the refiner a toll, or fee, for the refining. The metal is usually sold by the refiner on the concentrate producer's account; it is not general practice for the producer to take physical delivery of the metal. The contract specifies the price of zinc and the "payable metal", i.e. the proportion of metal that will be paid for; the balance is either lost in processing or if recovered belongs to the refiner. The contract also specifies the other values in the concentrate that will be paid for, and their price, as well as penalty clauses, escalation clauses and the conditions under which "force majeure" can be exercised. The escalation clause allows for adjustments to the toll, linked to the published price of zinc metal.

GOVERNMENT POLICIES

The Canadian Federal Government has introduced policies to upgrade Canada's natural resource exports. Major efforts include:

1) International bi-lateral negotiations towards a sectoral approach to reform the General Agreement on Tariffs and Trade, stressing vertical integration of a sector and aimed at maximizing trade liberalization;
2) Consideration of further processing as a criterion for accepting direct foreign investments under the Foreign Investment Review Agency (FIRA);
3) The enactment of Bill C-4, "An Act to Amend the Export and Import Permits Act" in May, 1974. This amendment enables the Federal Government to impose export controls to "ensure that any action taken to promote further processing in Canada is not rendered ineffective by reason of the unrestricted exportation of that natural resource".

At the provincial level, a number of governments have adjusted their mineral tax systems to provide incentives for further processing of mineral output. The most clear-cut and positive incentive for further processing is currently offered in Ontario under the recent revision of The Mining Tax Act. Under The Mining Tax Act, the processing allowance rates range up to 35% based on the undepreciated capital cost of processing assets.

The costs of processing concentrates outside of Canada will no longer be deductible for mining tax purposes, after 1979. In addition, Section 113 of The Mining Act of Ontario requires that all ores or minerals produced shall be treated and refined in Canada so as to yield refined metal or other product suitable for direct use in the arts without further treatment. Exemptions from this provision are granted by Cabinet on a case by case basis and each case is judged on its merits.

TRADE BARRIERS

Trade barriers, both tariff and non-tariff, represent an important constraint to the export of refined zinc metal from Canada, and hence a constraint to increased zinc metal production in Canada.

The EEC and Japanese markets impose tariffs on zinc metal imports whereas zinc in ore and concentrates are allowed to enter duty-free. A tariff of up to 10% ad valorem is applied to some categories of zinc-based alloys entering the EEC. Generally, an annually adjusted duty-free quota is set for refined zinc metal and only imports in excess of the quota are subject to the tariffs. The duty-free quota will be reduced to zero on July 1, 1977.

Until July, 1975, the U.S. was the only major market to impose a tariff on concentrates of zinc as well as zinc metal, however, the tariff on concentrates (0.67¢/lb of zinc) has been suspended until June 30, 1978. The tariff on zinc metal is 0.7¢/lb. of zinc, and a 19% ad valorem tariff is applied to zinc alloys.

Non-tariff barriers are considerably less obvious than tariffs, but none-the-less are effective impediments to the export of Canadian refined zinc. Japanese government measures are difficult to identify, however, their administrative guidelines ensure that Japan imports virtually no zinc metal. The United Kingdom has offered assistance, in the form of regional development programs, to encourage construction of a zinc refinery. In the U.S, non-tariff measures include anti-dumping regulations, custom classifications and government procurement practices.

Figure : I

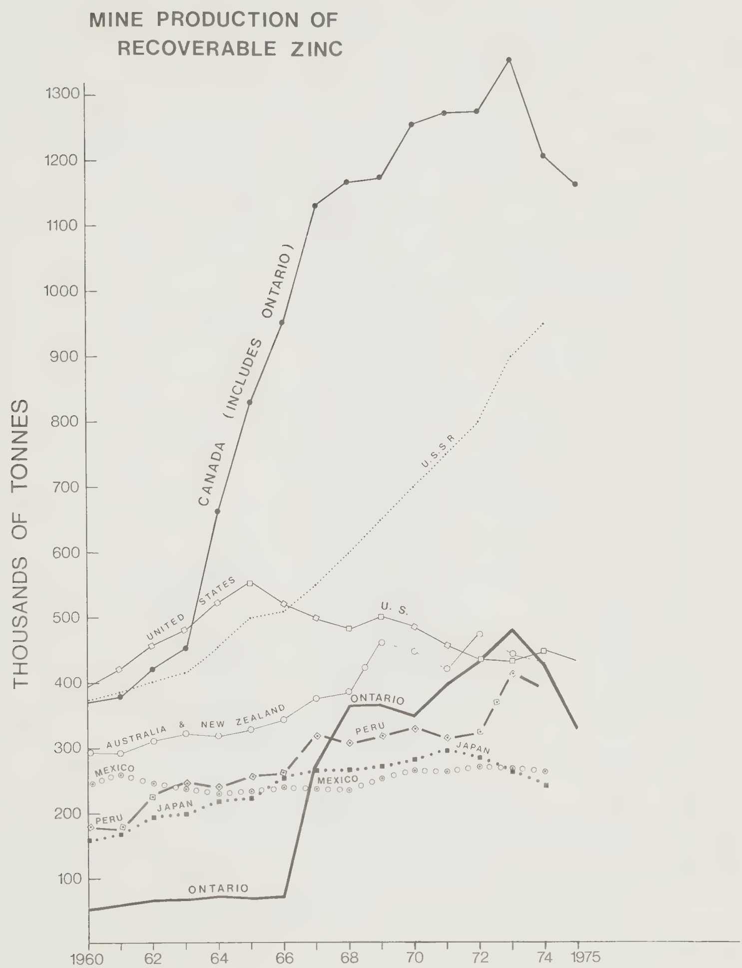

MINE PRODUCTION OF
RECOVERABLE ZINC
THOUSANDS OF TONNES
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
CANADA (INCLUDES ONTARIO)
U.S.S.R
UNITED STATES
U. S.
AUSTRALIA & NEW ZEALAND
ONTARIO
PERU
JAPAN
MEXICO
1960
62
64
66
68
70
72
74
1975

Figure : II

ONTARIO ZINC PRODUCTION

IN RELATION TO

CANADA AND WORLD

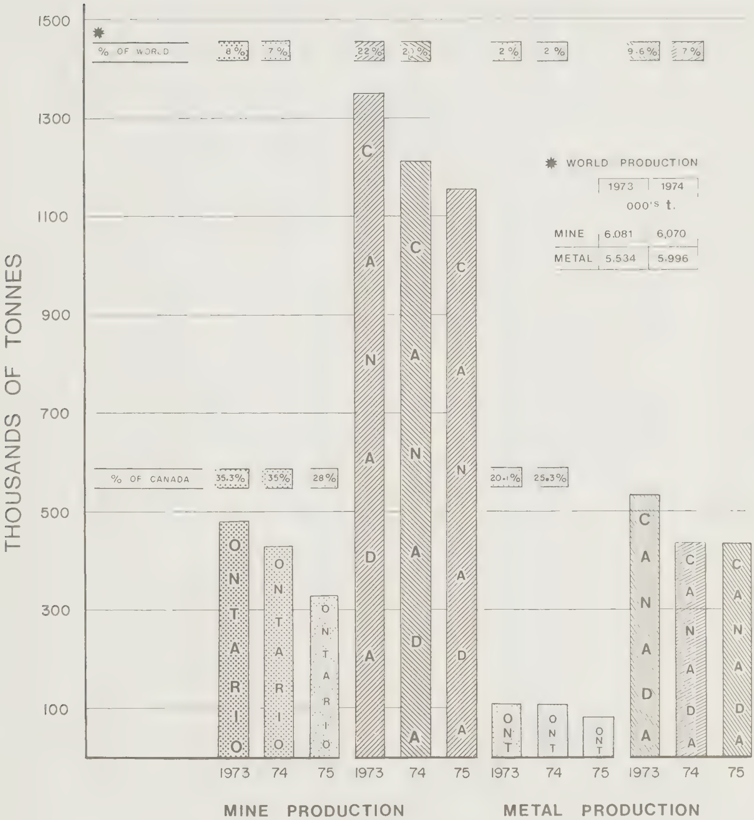
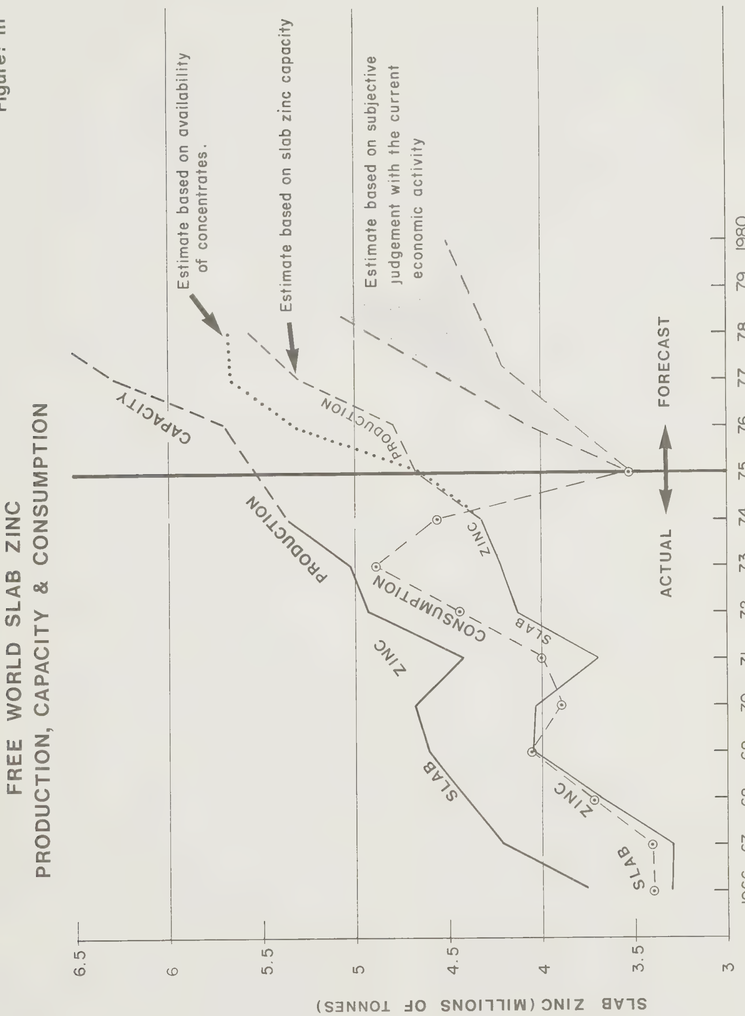


Figure: III


FREE WORLD SLAB ZINC
PRODUCTION, CAPACITY & CONSUMPTION
CAPACITY
SLAB ZINC PRODUCTION
SLAB ZINC CONSUMPTION
SLAB ZINC PRODUCTION
Estimate based on availability of concentrates.
Estimate based on slab zinc capacity
Estimate based on subjective judgement with the current economic activity
ACTUAL
FORECAST
SLAB ZINC (MILLIONS OF TONNES)
6.5
6
5.5
5
4.5
4
3.5
3
1966
67
68
69
70
71
72
73
74
75
76
77
78
79
1980

Chapter 2 Zinc Industry

2.1 World Zinc Industry

2.1.1 CONSUMPTION

Consumption of zinc in the Free World has grown at an annual compound rate of 5.5% since 1960, and reached a record high of 4 889 000 tonnes in 1973. The world-wide economic recession of 1974-75 resulted in a severe drop in the demand for zinc. Zinc consumption in the Free World declined to 3 517 000 tonnes in 1975 from 4 572 000 tonnes in 1974. Data for slab zinc consumption in the major parts of the Free World are given in Table 2.1.1 and illustrated in Figure 2.1.1. Consumption and production data for the USSR and other Communist countries are covered in Section 2.1.4.

Slab zinc consumption is related to economic activity in general; the automobile, appliance and construction industries particularly influence the consumption of die-castings, galvanized sheet, brass and rolled zinc products.

Zinc end-uses in the major markets, i.e. the United States, Europe and Japan are summarized in Table 2.1.2. Galvanizing, die-casting and brass are the three largest consuming end-use sectors. In 1974, the galvanizing industries of the U.S., Europe and Japan consumed 1 370 000 tonnes, the die-casting industries consumed 828 000 tonnes and the brass industries consumed 690 000 tonnes. The remaining demand for zinc was accounted for by rolled zinc, zinc oxide and other miscellaneous products. World end-use patterns have remained fairly stable since 1966, as the ratios of consumption between galvanizing, brass and die-casting sectors have not changed significantly.

Varying rates of growth have been observed in the Free World in different time periods; i.e. a compound annual rate of 2.9% in the 1950's; a 6.2% compound annual rate of increase during the 1960-1965 period and a period of adjustment for three years before rising at 9.7% and and 8.2% in 1968 and 1969, respectively. Slab zinc consumption during 1970 and 1971 declined, largely due to the economic slow-down in major consuming countries, price controls in the U.S. and international currency uncertainties. Demand for zinc intensified in the 1972-1973 period with the record boom in automobile production. Zinc consumption in major sectors of the Free World declined in 1974 and 1975 as a result of the economic recession; the 1975 consumption was estimated at 3 500 000 tonnes, and is expected to increase to 4 100 000 tonnes in 1976.

The three major zinc consuming markets of the Free World are Europe (the EEC), the United States and Japan; together, in 1975 these three consumed 2 760 000 tonnes representing 79% of the total Free World zinc consumption. Japanese zinc consumption has grown at an impressive 10.9% annual growth rate over the period 1960-1973. The U.S. remains the largest single market for slab zinc, however, its growth rate has been more modest at 4.2% per year. The European market has grown at an average rate of 3.9% during the same time period. Long-term growth rates in mature economies may lie between 3% and 4% per year when the effects of inflationary booms and subsequent recessions are taken into consideration.

2.1.2 ORE AND CONCENTRATE PRODUCTION

Zinc ore and concentrate production in the Free World increased by 66% to 4 240 000 tonnes in 1973 from 2 560 000 tonnes in 1960, representing a compound growth rate of 4.0% per annum. Major contributors to this increase in production of zinc ore and concentrate were Canada, Australia, Peru and Japan. Production of zinc ore, and concentrate in the United States and Mexico increased only at an annual rate of 0.7% during the 1960-1973 period. Table 2.1.3 summarizes the production data for these six countries and the Free World. The six countries, Canada, the U.S., Australia and New Zealand, Peru, Mexico and Japan together produced 3 040 000 tonnes or 72% of the total Free World production of zinc ore and concentrate in 1973. A dramatic growth in mine production of recoverable zinc occurred in the Free World in the 1964-1974 period. Figure 2.1.2 illustrates the major growth areas of mine production of recoverable zinc in the world. Movements of zinc ore and concentrates in the Free World are illustrated in Figure 2.1.3.

Canada is by far the World's largest producer of mined zinc and has continued to widen its lead since 1964. Canadian Mine production of 1 350 000 tonnes of recoverable zinc in 1973 represented 32% of the total Free World output. Australia and New Zealand together ranked a distant second in the Free World zinc ore and concentrate production with 440 000 tonnes in 1973. The United States, Peru, Mexico and Japan followed in that order.

The zinc industry of each of these countries is discussed in detail in Section 2.1.4.

2.1.3 SLAB ZINC PRODUCTION

Production of slab zinc in the Free World increased at an annual growth rate of 4.3% during the 1960-1973 period. Slab zinc production increased from 2 439 000 tonnes in 1960 to 4 279 000 tonnes in 1974. Table 2.1.4 summarizes the actual production of slab zinc in different parts of the Free World. Japan has demonstrated an impressive annual growth rate of 12.6% per annum over the period from 1960 to 1973 and was followed by Australia and Canada with annual compound growth rates of 7.3% and 6.4%, respectively over the same period. Contrary to the trend in other countries, the United States suffered a net decline in the same period; although production of slab zinc increased from 792 000 tonnes in 1960 to a record high of 1 008 000 tonnes in 1969, the slab zinc output dropped to 404 000 tonnes in 1975. This indicated a compound rate of decline of 2.5% per year in the U.S. slab zinc production from 1960 to 1973.

Despite large increases in Canada and Mexico, the total North American production of slab zinc showed only a marginal annual increase of 0.6% during the 1960-1973 period, reflecting the loss of production capacity in the

United States. The total European production of zinc metal increased from 923 000 tonnes in 1960 to 1 709 000 tonnes in 1974, representing an annual growth rate of 4.2%. Slab zinc movements in the Free World are shown in Figure 2.1.4.

2.1.4 MAJOR CONSUMERS AND PRODUCERS

Separate sections have been devoted to the United States, the world's largest zinc consumer and to Canada, the world's largest producer of zinc. The other major zinc consumers and producers are covered in this section and include: Europe, Japan, Australia, Peru, Mexico, Russia and other Communist Block countries.

EUROPE

Exploration: Exploration for zinc ore-bodies continues in the European countries where there are favourable tax environments. In particular, the Irish Government's liberal taxation policies (until mid-1974) with regard to mining operations, coupled with minimum restrictions for mineral acquisition and exploration created a favourable climate for risk capital required to develop Irish zinc-lead production facilities. Institution of a 20 year tax holiday for mining income resulted in the creation of a new industry with an initial output of 1500 tonnes of zinc in concentrate in 1965. Production of zinc further increased to a record high of 108 400 tonnes of zinc in concentrate by 1970. The discovery of Tara's Navan deposit in Ireland in 1970 was one of the most important zinc-lead discoveries ever made in Europe. Tara's development was delayed due to the Irish Government's policy changes which led to suspension of the project in August 1974. However, an agreement was reached between the Irish Government and Tara Mines Limited on the Terms of a State Mining Lease as follows:

1) A 25-year mining lease was granted to the company on the condition that *the Irish Government will get a free 25% equity interest in Tara Mines;*

2) *a royalty payment of 4.5% on pre-tax profits;* and

3) Profits from mining operations will be subject to company income taxes *at a rate of 50%.*

The outcome of all the above changes could curtail potential growth of mineral development in Ireland. After a long delay, zinc production from Tara is expected to commence in 1977 at an estimated cost of $150 million. The concentrator is designed to treat 6800 tonnes of ore per day and is expected to produce 200 000 tonnes of zinc in concentrate per year.

A widespread search for zinc is being carried out in Spain. Zinc concentrate production in Spain increased from 38 000 tonnes in 1965 to 94 000 tonnes of zinc in concentrates in 1974. Cominco, a Canadian-based company, owns 47% interest in the Rubiales Mine in Spain, which is being prepared for production at a rate of 60 000 tonnes of zinc in concentrate by mid-1977. This project is estimated to cost $43 million.

Ore and Concentrate: In Europe, Italy was self-sufficient in its zinc concentrate requirement up to 1969. Production of zinc concentrate declined from 131 000 tonnes in 1960 to 78 000 tonnes of zinc in concentrates in 1975, while Italy's zinc metal production increased to 210 000 tonnes in 1974. The main suppliers of zinc concentrates to Italy are Canada and Peru.

The total European production of concentrates increased from 574 000 tonnes of zinc in 1960 to 797 000 tonnes of zinc in 1975. Major zinc concentrate producers in Europe are: West Germany, Sweden, Spain, Denmark, (Greenland), Italy and Ireland. European imports of zinc ore and concentrates increased from 862 000 tonnes in 1968 to 1 100 000 tonnes in 1973 and is estimated at 1 174 000 tonnes in 1974 (see Table 2.1.5). The three major importers of zinc ore concentrate in Europe during 1974 were: West Germany with 313 000 tonnes, France with 298 000 tonnes and Belgium/Luxembourg with 254 000 tonnes.

Refined Zinc: The total refined zinc metal production in Europe increased by 43% from 1 191 000 tonnes in 1968 to 1 709 000 tonnes in 1974, representing a compound growth rate of 6.2% per annum. In 1969, West Germany surpassed Belgium and maintained its leading position in European zinc metal production (see Table 2.1.6). West German zinc metal production in 1974 is estimated at 400 000 tonnes, representing 23 % of the total European zinc metal output. Belgium is the second leading producer of zinc metal with 289 000 tonnes or 17% of the total European output and is followed by France and Italy. Despite the fact that Belgium is not blessed with producing mines, it has developed a vital zinc industry in Europe. Belgian zinc refining companies integrated backwards into mine production in other countries. There are three main producers of slab zinc in Belgium, and zinc concentrates are imported from Canada, Peru, West Germany, Sweden, France, Norway, Morocco and Zaire.

Australian zinc concentrate producers have been quite successful in extending their integrated operations forward to the prime metal stage in the European market. This was accomplished by establishing zinc smelter-refinery complexes in Europe through ownerhsip and joint-venture partnerships with European metal producers. These ventures facilitate securing a marketing outlet in the EEC and allow penetration through tariff and non-tariff barriers.

Cominco represents the first Canadian company to make an effort to integrate forward to the refining stage in the European zinc market. Cominco completed a feasibility study for the construction of an electrolytic zinc refinery, adjacent to the nuclear power station at Hartlepool, Tyneside, U.K. The operating capacity of this refinery is scheduled for an initial production of 100 000 tonnes of slab zinc annually at an estimated cost of $110 million, after receipt of government construction grants. Further decision, however, was deferred due to economic and political uncertainty. Cominco's plans for building a refining complex in Europe would provide a secure market for its zinc concentrate and result in tariff savings as zinc concentrate is allowed to enter free in the EEC while refined zinc is subject to an ad valorem tax of 3.5%.

Zinc Consumption: The total zinc metal consumption in the European sector was estimated at 1 380 000 tonnes in 1975 compared to a record high of 1 840 000 tonnes in 1973. This represented a drop of 25% in two years. The European zinc consumption increased at an annual compound growth rate of 3.9% during the period 1960-1973. Belgium, France, W. Germany and Italy together consumed 1 130 000 tonnes of slab zinc. Consumption growth rates in these four European sectors are shown in Table 2.1.1. Italy recorded a growth rate of 7.6% per annum in zinc consumption due to increased use in the gal-

vanizing sector and to the growth of the appliance industry, while Belgium and France indicated an annual growth rate of just over 4% during the period 1960-1973.

Principal end-users of zinc in Europe, in order of importance are: galvanizing, brass, die-casting and rolled zinc (see Table 2.1.2). The die-casting sector in European markets recorded the highest growth rate of 7.1% per annum rising from 125 000 tonnes in 1960 to 306 000 tonnes in 1973.

Europe offers a good potential for growth in zinc consumption, as it has developed into an automotive and appliance society. However, the traditional pattern of consumption may be altered.

The growth of zinc in brass and galvanizing may be moderated with the recent energy-related slow-down of the European economy. However, the escalating price behaviour of substitute materials, especially plastics and aluminum, could tip the balance in favour of zinc.

Slab zinc consumption in Europe surpassed the U.S. level in 1967 and the gap has continued to widen. A 559 000 tonnes margin over the U.S. consumption level was estimated for 1974.

The consumption of slab zinc for galvanizing in 1973 accounted for about 30% of the total European demand, and the compound growth rate in the period 1960 to 1973 was 4.5% per annum. Brass, the second main outlet in European zinc consumption, recorded a smaller compound growth rate of 3.3% per year over the same period to total 479 000 tonnes in 1973. Die-casting represented 17% of the total European consumption and grew at a compound rate of 7.1% per year from 125 000 tonnes in 1960 to 306 000 tonnes in 1973. All other end-uses of zinc accounted for 379 000 tonnes in 1960 which gradually increased to 508 000 tonnes in 1973 and recorded the smallest growth rate of 2.3% per annum.

Exports of zinc metal are summarized in Table 2.1.7. Belgium is the leading exporter of zinc metal in Europe with 194 000 tonnes in 1974 and 222 000 tonnes in 1973. West Germany, Finland, Norway and the Netherlands are among the major zinc exporters in the European sector (excluding the Communist Block).

JAPAN

Concentrates: Japan is the sixth largest producer of zinc in concentrate in the Free World, and is a major zinc concentrate importing country. Salient statistics on Japanese zinc production, imports and exports are summarized in Table 2.1.8. Japanese zinc ore and concentrate production rose at a modest compound growth rate of 4.1% from 157 000 tonnes in 1960 to 264 000 tonnes in 1973. In 1974, mined zinc production dropped to 241 000 tonnes. Domestic sources of zinc concentrate supply represented 31% of the Japanese requirement of 843 000 tonnes of zinc metal in 1973. The remainder of Japanese zinc concentrate needs were met by imports, mainly from Canada (37%), Peru (36%) and Australia (19%). The total zinc ore and concentrate imports into Japan showed a dramatic growth of 19% per annum from 57 500 tonnes in 1960 to 579 000 tonnes in 1973.

Slab Zinc: *Japan is the largest producer of slab zinc in the Free World.* Refined zinc metal production increased from 181 500 tonnes in 1960 to 850 000 tonnes in 1974, representing a compound growth rate of 12% per year. In 1975, Japanese slab zinc production declined by 17.5% to 701 000 tonnes due to production curtailment at several plants.

Toho Zinc Company owns the Annaka zinc refinery in Japan with an estimated annual capacity of 139 000 tonnes of electrolytic zinc. Nippon Mining Company has a large thermal zinc plant at Mikkaichi with a capacity of 120 000 tonnes of zinc per year. Akita Smelting Company, a consortium of 6 major Japanese refiners including Dowa Mining, Sumitomo Metal Mining and Nippon Mining has established an electrolytic zinc refining complex, which is the largest zinc refinery in Japan and one of the largest in the world. The Akita plant is a modern refinery with an annual capacity of 156 000 tonnes of slab zinc. This plant offers not only excellent recovery and grade of zinc and by-products, but it also meets ecological, safety and health standards, offers good working conditions and is strikingly pleasing in appearance.

Current Activities: Japanese companies continue to acquire interests in foreign zinc mining and refining operations: Toho Zinc Company, Mitsui Mining and Smelting Company, Merubeni and Iidia are participating in joint-ventures in developing mines in Peru. Dowa Mining Company, jointly with I.M.M. is establishing a zinc smelter-refinery complex in Mexico, and Nippon Mining Company and Mitsui are prospecting for zinc in Saudi Arabia.

Slab Zinc Consumption: Slab zinc consumption in Japan declined to 542 000 tonnes in 1975 from 699 000 tonnes in 1974. The growth of zinc consumption in Japan over the period 1960 to 1973 has been quite impressive with an average 10.9% annual compound rate of increase. Consumption grew from 198 000 tonnes in 1960 to 759 000 tonnes in 1973. In the same period the demand for zinc in the galvanizing sector showed a remarkable increase from 114 000 tonnes to 376 000 tonnes, (see Table 2.1.2) and continues to represent over 50% of the total Japanese zinc consumption. The use of zinc for die-casting has recorded a steady growth in the automobile, appliances, electrical and communication equipment areas and accounted for 169 000 tonnes or 22% of the total consumption in 1973. This is partly reflected in the growth in automobile production from 1 780 000 units in 1964, to 7 081 000 units in 1973. However, in 1974, production of automobiles dropped to 6 548 000 units which affected zinc consumption in Japan.

Exports: The exports of refined zinc metal achieved a record compound growth rate of 24% per annum from 6000 tonnes in 1960 to 116 000 tonnes in 1974. Of the total zinc exported, approximately 44% or 50 800 tonnes were shipped to the U.S. during 1974. The Japanese exports of slab zinc declined to 53 000 tonnes in 1975.

In 1976, exports of slab zinc have been increasing gradually with total shipments of 3362 and 4247 tonnes in January and February, respectively. The Japanese zinc smelters have exported 6000 tonnes of slab zinc to the USSR in April, 1976. A further shipment of 6000 tonnes to the USSR was negotiated for June delivery. The contract was to be settled on the basis of the L.M.E. price.

In early April, 1976, the Japanese quoted market price for electrolytic zinc (Tokyo, ex-warehouse) was 245 000 yen per tonne (equivalent to U.S. $820 per tonne at the current exchange rate). The European Producer Price was U.S. $795 per tonne (36¢/lb.).

AUSTRALIA AND NEW ZEALAND

Australia and New Zealand together rank as the third largest producer of zinc in concentrates in the Free World. The Australian zinc industry along with other mineral production enjoyed a rapid growth under stable and attractive mineral and foreign investment policies over a period of 23 years prior to December, 1972, when the new Labour Government changed the domestic environment for the inflow of foreign capital. Australian mineral tax incentives were similar to those of the United States and of Canada prior to the federal and provincial tax changes in the last 5 years.

Under the Australian Labour Government, during the 1972–1975 period, a number of long-standing tax incentives for mineral development were withdrawn and disincentive measures introduced. They can be summarized as follows:

- tax advantages available to individual Australians, investing risk capital in exploration were removed;
- a capital gains tax was instituted on specific profits, which resulted in an increase in the cost of exploration funds;
- certain write-offs, which had contributed towards the rapid growth of the Australian mining industry over a 23 year period, were disallowed, resulting in a reduced rate of return on mining investments;
- restrictions on capital inflow, foreign ownership and control of Australian mineral resources;
- government's participation in mineral development.

Major changes in government policies and mineral laws hinder developments by increasing the uncertainty, and compounding the already high discovery costs and long lead times required to bring new production facilities on stream.

In December 1975, the Australian Liberal and National Country Party replaced the former Labour Government; the new government has stated that major policy changes will be made in the mineral resource sector. The main strategy to revive investment will be by means of a range of new incentives in the field of natural resources. The program of the former Labour Government for a government-owned Petroleum and Minerals Authority is to be discarded. However, the new policy on minerals will continue the labour approach of encouraging the maximum practicable degree of domestic mineral processing.

Concentrates: In 1974, concentrate production was estimated at 427 000 tonnes of contained zinc and accounted for 10% of total Free World production. Mine production increased from 295 000 tonnes in 1960 to 441 000 tonnes in 1973, and represented an annual compound growth of 3.1%. Comparative production data are presented in Table 2.1.3.

Slab Zinc: The first refining complex was established in 1916 by Electrolytic Zinc Company of Australia to treat the zinc concentrates from the lead-zinc mines at Broken Hill, New South Wales. The plant was designed to treat the zinc concentrates by the then newly-developed electrolytic process on a large pilot plant scale. The plant capacity has been expanded over the intervening period and now has a productive capacity of 210 000 tonnes per year.

A second zinc refining complex was established in Australia in the early 1960's by Sulphide Corporation, a wholly owned subsidiary of Australian Mining and Smelting Company. This plant was designed to use the Imperial Smelting Furnace (ISF) process at an annual capacity of 62 000 tonnes. Broken Hill Associated Smelters Limited built a third zinc refining complex in 1972 with an annual capacity of 40 000 tonnes.

Zinc metal production in Australia declined to 262 000 tonnes in 1974 from 306 000 tonnes in 1973, due to softening demand for zinc on the international market. This represented 61% and 70% of total zinc concentrate production in 1973 and 1974, respectively. Slab zinc production in Australia grew at a compound rate of 7.3% per annum from 122 000 tonnes in 1960 to 306 000 tonnes in 1973.

Zinc metal consumption in Australia and New Zealand declined 3.9% to 139 000 tonnes in 1974 from 144 000 tonnes in 1973.

Exports: In 1974, Australian zinc exports were 223 000 tonnes of zinc in concentrate and 162 000 tonnes of slab zinc metal.

Another subsidiary of Australian Mining and Smelting Company, Commonwealth Smelting Limited, acquired the zinc refining complex of the Imperial Smelting Corporation Limited at Avonmouth, U.K., in 1973. The Australian Mining and Smelting Company is a subsidiary of Conzinc Rio Tinto of Australia which in turn is a subsidiary of the Rio Tinto Zinc Corporation Ltd., U.K. Australian Overseas Smelting Pty. Ltd., another subsidiary of the Australian Mining and Smelting Company, in a joint-venture partnership with Billiton N.V., commissioned an electrolytic zinc plant in 1974 at Budel, Netherlands, with a rated capacity of 136 000 tonnes of slab zinc per year. These efforts are intended to provide a secure market for Australian zinc concentrates in the European Economic Community.

PERU

Peru continued to maintain its fourth position in the Free World in zinc concentrate production since 1963. Peru's zinc concentrate production reached a record high of 412 000 tonnes in 1973, representing 9.7% of the total Free World Production. The largest zinc mining company in Peru was Cerro de Pasco Corporation of New York, which was taken over by the Government of Peru in December, 1973. All the activities of acquired operations are now carried on by a newly formed state enterprise, known as Centromin Peru. Centromin's production of zinc in ore and concentrate in 1973 was about 182 000 tonnes or 44% of the total zinc concentrate production in Peru.

The shift of ownership of many Peruvian mining operations to the State agencies since the early 1970's resulted in uncertainty among private investors. However, mineral production remains Peru's major foreign exchange earner and represents the government's priority area for further development. Expansion of existing facilities and development of new properties will require hundreds of millions of dollars in foreign capital which will have to be raised in the next five years. The second largest mining

company in Peru is Asarco of the U.S., through its subsidiary Northern Peru Mining. These operations are on a fairly small scale at Quiruvilca and Trufillo. Zinc concentrates produced at these mines are exported. Japanese companies, particularly Toho Zinc Limited and Mitsui Mining and Smelting Company began investing in Peruvian zinc mining in the late 1960's and are continuing to invest on a quite large scale in the development of zinc mining in Peru.

Concentrates: Preliminary estimates indicate a 6% drop in concentrate production to 387 000 tonnes in 1974. Table 2.1.3 compares the production data and indicates a growth rate of 6.7% in Peru for the period 1960–1973.

Slab Zinc: Peru's only zinc smelting-refining complex is located at La Oroya. Previously owned by Cerro de Pasco, it was taken over by Centromin. The plant uses the electrolytic process and presently has an annual capacity of 78 000 tonnes of refined zinc. Plans have been announced to expand the plant by 20% to a capacity of 90 000 tonnes per year, at an estimated cost of $65 million. Canadian interests (commercial banks and the Export Development Corporation) have formally offered to finance virtually 100% of the expansion. Recently a subsidiary of Metallgesellschaft A.G. of West Germany has prepared a feasibility study for a zinc refining complex at Cajamarquilla, north of Lima. This plant was approved by the Peruvian government, and Minero Peru, the state mining company, is attempting to arrange financing. The plant is to be designed for a capacity of 89 000 tonnes. Capital costs are estimated to be in the range of $42 to $70 million.

In 1974, zinc metal production in Peru was reported at 70 800 tonnes, which accounted for 18% of total Peruvian zinc concentrate production. Zinc metal consumption in Peru was reported at 27 300 tonnes in 1973, and estimated at 29 000 tonnes for 1974. The reported consumption increased from 6000 tonnes in 1972 to 27 300 tonnes in 1973 as a result of a LAFTA (Latin American Free Trade Association) agreement with Brazil where die-casting alloy is manufactured in Peru and exported to Brazil.

Exports: Peru is one of the major zinc-exporting countries in the Free World. Exports of zinc in concentrates were 367 700 tonnes and in slab zinc metal were 35 900 tonnes in 1973. In 1974 exports of concentrates were 355 000 tonnes of zinc content and 42 500 tonnes of slab zinc.

MEXICO

Mexican production of zinc has been maintained at a level between 228 000 and 270 000 tonnes per year since 1960 (see Table 2.1.3). The stable tax and foreign investment policies of the Mexican government have been major factors in maintaining this production level. Mining and processing operations in Mexico must be at least 51% Mexican-owned, and in the future the required Mexican ownership will be increased to 66%. Constraints to foreign investment, though considerable, are definite and limited, particularly as regards return on such investment. Thus, in spite of a 20% withholding tax on remittance of dividends on foreign capital, uncertainty on the inflow of risk capital into Mexico has been minimized.

The Federal income tax applied to the mining industry is the same as that applied to all other industries–a graduated rate from 5% to 42%; the top rate is reached at a taxable income of $120 000. This, of course, is in addition to the production, export and land taxes.

The other taxes paid by the mining industry in Mexico are:

- a tax on mining concessions computed on the surface area at an annual rate of $1.20 per hectare (2.47 acres);
- production and export taxes paid in accordance to the International Market price.

Production and export taxes vary from 0.86% to 6.64% depending on the mineral and the level of processing, and tax rates are imposed on market prices of minerals. However, reduction in the rate of this tax may be authorized by the Secretariat of Finance in the following manner:

- exploitation of new mines or mines which have been inactive over a period of at least 10 years would qualify for a reduction in tax rate for 5 years–a 50% reduction in the first two years; a 30% reduction for the next two years and 10% reduction for the fifth year;
- the production tax on gold and silver may be reduced by 75% of the normal rate, if these metals are produced as by-products in concentrates with a zinc content of 40% or more.

These rates are negotiated on a case-by-case basis. Incentives offered to encourage mining activities include subsidies to assist small and medium mining producers dependent on the net Federal tax. Other stimuli offered to mining investors may consist of a reduction of production and export taxes up to 100%, in the case of Mexicanized companies; a reduction of up to 10% in the income tax may be granted to those companies engaged in exploration activities. Accelerated depreciation is also allowed on capital assets.

Concentrates: The four major zinc producing companies in Mexico are: Industria Minera Mexicana (IMM), formerly known as Asarco Mexicana; Industrias Penoles, S.A.; Cia Fresnillo; and Minera Frisco S.A. Production of concentrate in Mexico dropped to 261 000 tonnes of contained zinc in 1974 from 266 000 tonnes in 1973, representing 6.3% of the Free World's mined zinc output in those years (see Figure 2.1.2).

Industria Minera Mexicana (IMM) increased its Mexican domestic participation in Asarco Mexicana from 51% to 66% during the first half of 1974. Asarco of New York retains the 34% interest in the original company which has changed its name to Industria Minera Mexicana. IMM has a number of mines throughout the country but its main producing mines are in the north and south. Production of zinc concentrate from the mines owned by IMM expanded steadily from 92 000 tonnes in 1968 to 124 000 tonnes in 1972.

Industrias Penoles S.A., (previously known as Metalurgica Mexicana Penoles S.A.), is a wholly Mexican owned company, which has several mines in central and northern Mexico. In addition to its own operations, Penoles has a 51% interest in Cia Fresnillo S.A. and the remaining 49% is owned by the U.S. Fresnillo Company of New York. The company produced 42 200 tonnes of zinc concentrates in 1972, all of which were exported. American Zinc Company in the U.S. purchased this concentrate prior to its closure

in 1971. However, satisfactory contracts with the Japanese and European smelters were made to dispose of the accumulated stockpile of zinc concentrates. On completion of the new Industrias Penoles smelter, all zinc concentrates from Fresnillo will be purchased by Penoles.

Minera Frisco S.A. is a wholly Mexican owned company with several interests in other mining companies in Mexico. Zinc concentrates are sold to Zincamax S.A. and Amax.

Slab Zinc: Zinc smelter-refinery complexes are owned by: Zinc Industrial S.A., a subsidiary of IMM; Industrias Penoles; Zincamax, S.A., and Mexican Zinc Company. Zincamax is a State-owned company which operates a horizontal retort plant with an annual capacity of 27 200 tonnes of slab zinc. Mexican zinc metal production was estimated at 135 000 tonnes while consumption was reported to be 70 000 tonnes in 1974. The remaining zinc metal is exported.

Industria Minera Mexicana (IMM) is expecting commencement of production from the $150 million San Luis electrolytic zinc plant by 1979. The plant is to have a capacity of 115 000 tonnes per year.

Exports: Mexican exports of zinc in concentrate form reached a record high of 173 000 tonnes of zinc content in 1970 but declined to 118 000 tonnes of zinc in concentrate in 1973. The major importing countries of Mexican zinc concentrates are the U.S. and Japan.

THE COMMUNIST COUNTRIES

Ore and Concentrate Production: The USSR is the second largest producer (next to Canada) of zinc in ore and concentrates in the world with an estimated output of 950 000 tonnes in 1974. This represented 15.5% of the total world production of zinc in ore and concentrate form.

Russian zinc mine production doubled between 1964 and 1974. About 40% of the USSR zinc output is produced by the Kazakhstan area, where new mines and major expansions in operating mines occurred during the period between 1971 and 1975. Other production facilities are at the Zyryanovsk and Achisay polymetallic complexes. The Leninogorsk and the Mirgalinsk, Tekeli and Kasakaygyr zinc-lead complexes were planned to increase zinc production between 1973 and 1975.

Poland, North Korea, China and Bulgaria, respectively are other major zinc ore and concentrate producers in Communist countries. Table 2.1.9 summarizes the zinc output in the Communist countries for the period 1970 to 1975. The total 1975 production of zinc in these countries is estimated at 1 625 000 tonnes.

Slab Zinc Production: The estimated output of slab zinc in the USSR was 980 000 tonnes during 1974. Poland produced about 240 000 tonnes of slab zinc while China and North Korea each produced 130 000 tonnes in 1974. Table 2.1.10 shows the slab zinc production trend in Communist countries from 1970 to 1975. The total output of slab zinc increased from 1 120 000 tonnes in 1970 to 1 650 000 tonnes in 1974.

Consumption and Trade: Russian zinc consumption more than doubled from 390 000 tonnes in 1964 to 880 000 tonnes in 1974. China and Poland consumed 200 000 and 160 000 tonnes of zinc respectively in 1974. Table 2.1.11 summarizes the slab zinc consumption pattern in the Communist countries.

In 1973, Russia imported 44 700 tonnes of zinc in concentrates and 44 800 tonnes of slab zinc. The total exports of slab zinc from Russia during 1973 were estimated at 146 000 tonnes of which approximately 70 000 tonnes were exported to western countries. Table 2.1.12 presents Russian zinc imports and exports for the period from 1970 to 1974. The total exports of slab zinc from the Communist Block countries to western countries reached 179 000 tonnes in 1973 and dropped to 124 000 tonnes in 1974 (see Table 2.1.13).

Figure 2·1·1

SLAB ZINC CONSUMPTION

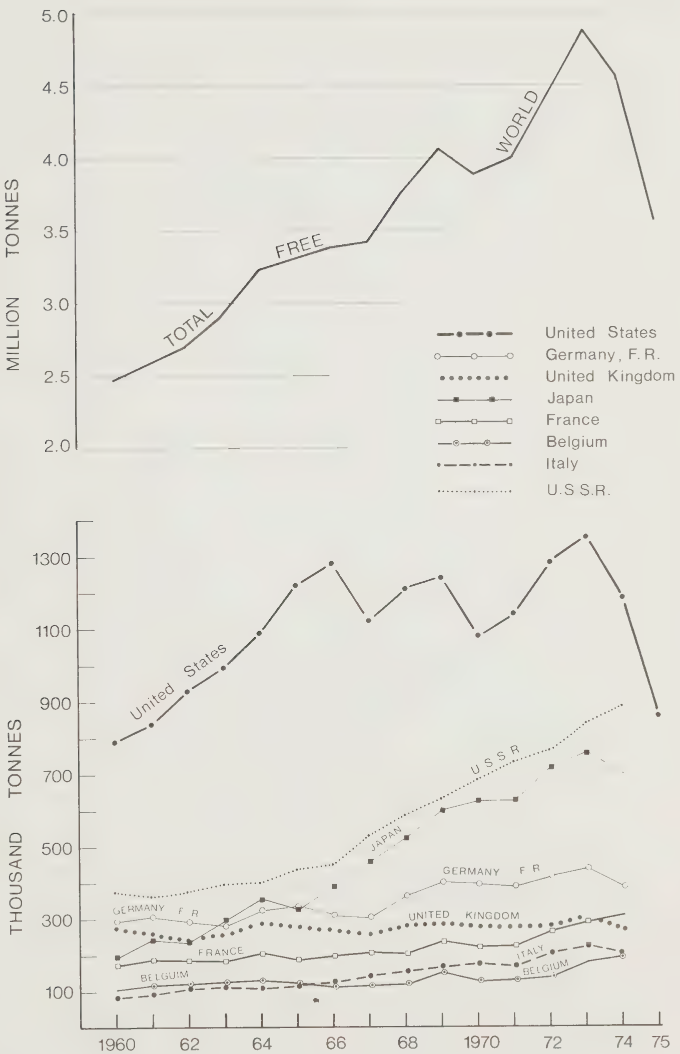


Figure 2.1.2

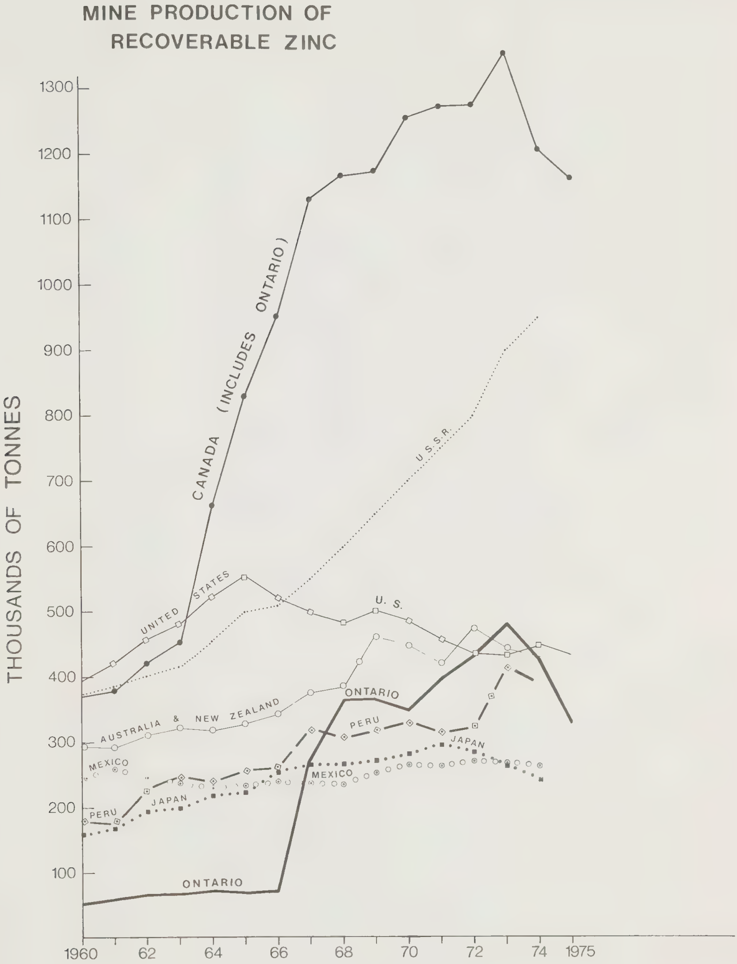

MINE PRODUCTION OF
RECOVERABLE ZINC
THOUSANDS OF TONNES
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
1960
62
64
66
68
70
72
74
1975
CANADA (INCLUDES ONTARIO)
U.S.S.R.
UNITED STATES
U. S.
AUSTRALIA & NEW ZEALAND
ONTARIO
PERU
JAPAN
MEXICO
MEXICO
JAPAN
PERU
ONTARIO

Figure 2.1.3

WORLD ZINC ORE AND CONCENTRATE MOVEMENTS

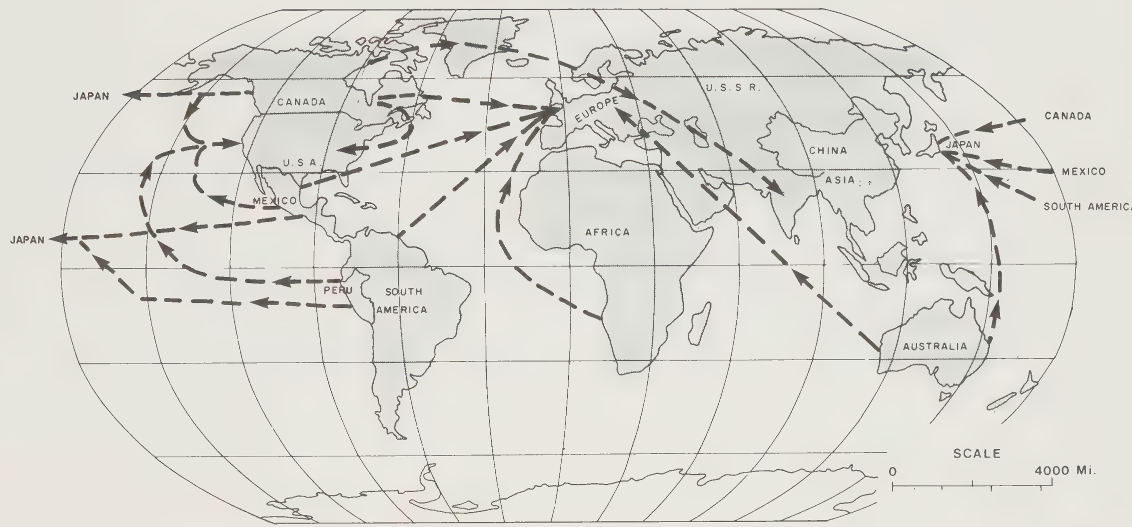


Figure 2.1.4

WORLD SLAB ZINC MOVEMENTS

TABLE 2.1.1

TOTAL SLAB ZINC CONSUMPTION

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975P	ANNUAL COMPOUND GROWTH RATE 1960 - 1973
	(10^3 Tonnes)																%
Belgium	105	115	121	123	131	123	110	116	119	150	128	131	139	180	195	115	4.2
France	172	189	186	181	204	186	197	203	202	239	220	225	264	290	306	218	4.1
Germany, F.R.	297	306	291	280	321	334	310	303	362	400	396	388	413	438	386	340	3.0
Italy	85	90	106	110	108	116	123	141	155	167	178	170	203	220	202	150	7.6
Japan	198	244	234	295	356	322	389	458	523	600	623	624	717	759	699	542	10.0
United Kingdom	276	258	245	258	288	278	268	256	280	287	278	274	277	302	268	205	0.7
United States	796	838	929	996	1,089	1,221	1,279	1,122	1,210	1,241	1,077	1,138	1,287	1,351	1,169	840P	4.2
TOTAL FREE WORLD	2,454	2,586	2,701	2,906	3,230	3,308	3,390	3,418	3,752	4,060	3,890	3,990	4,413	4,889	4,572	3,517	5.5

SOURCE: The International Lead and Zinc Study Group
Annual Reviews – Zinc Institute Inc.
The U.S. Bureau of Mines
World Bureau of Metal Statistics
P – Preliminary

TABLE 2.1.2

ZINC CONSUMPTION (BY MAJOR END-USE)

	1960	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975P	ANNUAL COMPOUND GROWTH RATE 1960 - 1973
	(10^3 Tonnes)											(%)
EUROPE												
Galvanizing	309	356	373	384	452	445	451	490	549	516		+ 4.5%
Brass	314	328	312	349	392	387	391	424	479	449		+ 3.3%
Die-Casting	125	180	177	207	251	252	253	274	306	285		+ 7.1%
Other	379	406	386	293	443	389	438	437	508	478		+ 2.3%
TOTAL EUROPE	1,127	1,270	1,248	1,333	1,539	1,473	1,533	1,662	1,841	1,728	1,383P	+ 3.9%
JAPAN												
Galvanizing	114	227	225	287	327	338	338	382	376	381		+ 9.6%
Brass	30	52	60	66	73	77	76	90	105	75		+10.1%
Die-Casting	20	56	82	98	118	115	115	144	169	144		+17.8%
Other	34	53	62	71	82	93	95	101	109	99		+ 9.4%
TOTAL JAPAN	198	389	458	523	600	623	624	717	759	699	542P	+10.9%
U.S.A.												
Galvanizing	337	450	416	437	432	430	431	470	500	475	318	+ 3.1%
Brass	96	168	119	147	163	116	137	174	178	166	103	+ 4.9%
Die-Casting	311	550	485	511	523	421	468	526	558	399	285	+ 4.6%
Other	53	111	101	115	123	110	102	117	115	129	134	+ 6.1%
TOTAL U.S.A.	796	1,279	1,122	1,210	1,241	1,077	1,138	1,287	1,351	1,169	840P	+ 4.2%

Source: U.S. Bureau of Mines
Annual Reviews – Zinc Institute Inc.
Lead and Zinc Statistics – International Lead and Zinc Study Group

P – Preliminary

TABLE 2.1.3

MINE PRODUCTION OF RECOVERABLE ZINC

YEAR	U.S.	MEXICO	PERU	JAPAN	AUSTRALIA & NEW ZEALAND	CANADA(1) (INCLUDES ONTARIO)	*ONTARIO(1)*	TOTAL FREE WORLD
				(10^3 Tonnes)				
1960	395.0	243.6	178.0	156.7	294.8	369.1	*41.0*	2,562.5
1961	421.3	258.1	173.8	168.2	292.8	377.4	*47.1*	2,649.3
1962	458.6	245.0	226.6	192.5	310.3	420.2	*57.3*	2,800.3
1963	480.1	235.5	246.8	198.0	321.3	429.8	*60.3*	2,856.1
1964	521.5	228.3	236.7	216.5	318.5	621.0	*65.4*	3.158.2
1965	554.4	233.0	254.5	221.0	326.4	745.7	*55.0*	3,418.8
1966	519.4	238.4	257.8	253.4	342.2	874.6	*74.7*	3.572.6
1967	498.4	236.6	317.9	262.7	374.3	1,008.3	*259.9*	2,622.3
1968	480.3	235.8	303.3	264.3	384.6	1,051.8	*314.6*	3,720.9
1969	501.8	251.6	315.0	269.4	460.5	1,095.5	*326.8*	3,921.2
1970	484.6	263.0	329.0	279.7	446.8	1,135.7	*308.7*	4,042.9
1971	455.9	261.2	311.4	294.4	417.0	1,133.7	*331.8*	4,020.5
1972	433.9	269.4	320.0	281.1	472.2	1,128.7	*358.2*	4,072.9
1973	434.4	266.0	412.0	264.0	440.5	1,226.2	*414.0*	4,241.8
1974	453.5	261.0	387.0	240.9	427.2	1,159.5	*422.1*	4,151.6
1975P	430.0	221.0	360.0	253.6		1,052.0	*337.0*	
Annual Compound Rate of Growth 1960-1973	0.7%	0.7%	6.7%	4.1%	3.1%	10.5%	*18.8%*	4.0%

Source: The U.S. Zinc Industry, U.S. Bureau of Mines Information Circular 1974
The International Lead and Zinc Study Group – Monthly Statistics
EMR – Annual Reviews

(1) Estimated recoverable zinc in Ores and Concentrates shipped for export plus new refined zinc produced from domestic primary materials (concentrates, slag, residues, etc.)

P – Preliminary

TABLE 2.1.4

SLAB ZINC PRODUCTION

YEAR	CANADA	UNITED STATES	MEXICO	*TOTAL NORTH AMERICA*	PERU	*TOTAL SOUTH AMERICA*	BELGIUM	FRANCE	GERMANY F.R.	ITALY	U.K.	*TOTAL EUROPE*	*TOTAL ARFICA*	JAPAN	*TOTAL ASIA*	AUSTRALIA	*TOTAL FREE WORLD*
						(10³ Tonnes)											
1960	237	792	53	*1,082*	33	*49*	246	149	192	85	76	*923*	*83*	181	*181*	122	*2,439*
1961	243	818	52	*1,113*	32	*40*	244	162	195	85	94	*967*	*88*	212	*212*	141	*2,570*
1962	254	851	56	*1,161*	33	*52*	205	164	181	83	99	*927*	*96*	245	*245*	171	*2,655*
1963	257	864	57	*1,178*	56	*76*	206	168	166	77	101	*921*	*103*	282	*282*	183	*2,739*
1964	306	931	59	*1,196*	62	*85*	221	190	167	74	111	*970*	*101*	316	*316*	189	*2,956*
1965	325	978	63	*1,366*	63	*86*	238	192	182	81	107	*1,007*	*101*	368	*368*	202	*3,130*
1966	347	1,005	72	*1,424*	64	*86*	249	196	209	77	101	*1,044*	*103*	444	*444*	197	*3,298*
1967	368	918	74	*1,360*	63	*87*	224	186	182	89	105	*1,018*	*106*	516	*516*	198	*3,284*
1968	387	999	83	*1,369*	68	*92*	247	208	203	112	143	*1,191*	*116*	606	*629*	213	*3,709*
1969	423	1,008	83	*1,514*	65	*95*	257	254	278	130	151	*1,359*	*126*	712	*739*	253	*4,086*
1970	413	866	81	*1,360*	71	*126*	232	224	301	142	147	*1,381*	*145*	676	*703*	268	*3,984*
1971	372	769	83	*1,224*	59	*107*	208	219	263	139	117	*1,273*	*164*	716	*748*	266	*3,782*
1972	476	641	84	*1,201*	70	*127*	254	262	359	156	74	*1,474*	*170*	805	*841*	304	*3,116*
1973	533	570	72	*1,175*	70	*129*	277	259	395	182	84	*1,572*	*173*	843	*877*	306	*4,231*
1974	438	575	135	*1,089*	71	*136*	289	276	400	210	84	*1,709*	*185*	850	*891*	262	*4,279*
1975P	427	404	150		62		221	190	300	180	62	*1,476*		701	*740*	192	*3,788*
Annual Compound Rate of Growth (%) 1960-1973	6.4%	-2.5%	2.4%	0.6%	6.0%	7.7%	0.9%	4.3%	5.8%	6.0%	0.8%	4.2%	5.8%	12.6%	12.9%	7.3%	4.3%

Source: The International Lead Zinc Study Group
E.M.R.
U.S.B.M.
P – Preliminary

TABLE 2.1.5

EUROPEAN IMPORTS OF ZINC ORE AND CONCENTRATES

(Tonnes)

COUNTRY	1968	1969	1970	1971	1972	1973	1974E
Austria	4,900	6,700	3,300	1,600	500	300	200
Belgium/Luxembourg	267,400	250,000	205,000	256,200	233,000	284,000	253,900
France	209,100	240,000	238,400	223,300	253,200	269,800	297,700
West Germany	115,300	171,300	177,700	173,500	245,000	304,100	312,600
Netherlands	52,500	55,100	49,700	53,800	43,800	59,100	113,800
Norway	46,500	51,800	64,400	82,500	120,400	121,100	86,800
United Kingdom	166,700	164,900	154,300	136,000	59,300	62,300	109,700
TOTAL EUROPEAN IMPORTS	862,400	939,800	892,800	926,900	955,200	1,100,700	1,173,800

Source: Lead – Zinc Statistics
International Lead Zinc Study Group
E – Estimate

TABLE 2.1.6

EUROPEAN REFINED ZINC METAL PRODUCTION

(Tonnes)

COUNTRY	1968	1969	1970	1971	1972	1973	1974E
Austria	15,300	15,500	16,000	16,000	16,900	17,000	17,300
Belgium	247,300	257,400	231,900	207,900	254,200	276,600	288,800
Finland	–	1,100	55,800	63,700	81,100	79,900	91,300
France	207,500	253,500	223,700	218,700	261,500	259,400	276,500
West Germany	202,700	278,000	301,200	262,600	358,700	395,000	400,000
Italy	112,300	130,300	142,100	138,900	155,900	182,000	196,400
Netherlands	42,500	46,300	46,700	44,000	48,300	30,500	78,200
Norway	60,100	58,800	61,700	62,500	73,300	80,500	71,900
Spain	81,400	86,200	94,100	97,100	108,000	108,500	125,700
United Kingdom	142,900	151,000	146,600	116,500	73,800	83,900	84,400
Yugoslavia	79,000	81,000	61,100	45,500	41,900	58,500	78,200
TOTAL EUROPEAN REFINED ZINC PRODUCTION	1,191,000	1,359,100	1,380,900	1,273,400	1,473,600	1,571,800	1,708,700

Source: International Lead Zinc Study Group

E – Estimate

TABLE 2.1.7

ZINC METAL EXPORTS

(Tonnes)

EUROPE	1968	1969	1970	1971	1972	1973	1974
Austria	4,600	2,000	300	600	600	-	500
Belgium	151,400	155,500	137,300	126,800	192,700	221,700	193,600
Denmark	–		–	-	–	10,500	300
Finland	100	100	5,000	56,100	67,800	65,000	67,000
France	20,200	20,000	16,400	29,300	48,500	37,100	25,100
West Germany	27,400	28,900	47,400	38,200	91,200	91,600	63,300
Italy	900	800	1,900	100	100	5,000	20,700
Netherlands	21,700	25,600	23,200	28,400	43,700	34,700	60,700
Norway	50,300	41,700	46,400	48,600	58,500	54,400	45,300
Spain	19,800	4,200	6,000	18,600	5,200	300	4,100
United Kingdom	22,100	13,800	11,900	11,100	15,800	20,100	7,900
Yugoslavia	30,100	30,400	21,900	19,800	22,300	28,000	39,700
Communist Block (E)							
Bulgaria	40,300	38,800	38,300	38,100	28,900	26,000	30,000
Poland	73,200	81,700	79,600	76,900	84,000	84,400	79,400
U.S.S.R.	78,600	85,700	95,300	124,000	132,000	146,300	116,500
AFRICA							
Zambia	38,900	50,600	50,300	50,500	59,500	49,000	47,900
South Africa, Rep.	–	–	–	–	200	1,900	4,000
AMERICA							
Mexico	37,200	38,800	35,800	42,000	38,700	10,800	
Peru	55,100	57,700	65,000	49,700	54,000	35,900	42,500
JAPAN	85,200	90,400	52,600	63,000	106,600	65,000	116,100
AUSTRALIA	98,700	140,600	145,300	155,200	206,100	195,200	161,600

Source: Monthly Bulletin of The International Lead and Zinc Study Group

E – Estimate

TABLE 2.1.8

JAPANESE
SALIENT ZINC STATISTICS

	1960	1966	1967	1968	1969	1970	1971	1972	1973	1974E	1975P	ANNUAL COMPOUND GROWTH RATE 1960-1973
	(10^3 Tonnes)											%
Domestic Ore & Concentrate Production	157	253	263	264	269	280	294	281	264	241	254	4.1%
Ore & Concentrate Imports (Metal content)	58	212	275	409	435	457	477	509	579	652	457	19.4%
Refined Metal Production	181	444	516	606	712	676	716	805	843	850	701	12.7%
Refined Metal Exports	6	55	65	85	90	53	63	107	65	116	53	20.1%
Refined Metal Consumption	198	389	458	523	600	623	624	717	759	699	542	10.9%

Source: World Bureau of Metal Statistics
Lead and Zinc Statistics, International Lead & Zinc Study Group.

P – Preliminary
E – Estimate

TABLE 2.1.9

U.S.S.R. AND OTHER COMMUNIST COUNTRIES MINE PRODUCTION OF ZINC

	1970	1971	1972	1973	1974	1975P
	(Tonnes)					
U.S.S.R.	700,000	750,000	800,000	900,000	950,000	960,000
Poland	241,200	236,400	222,400	210,000	200,000	216,000
Bulgaria	76,400	80,000	80,000	80,000	80,000	84,000
East Germany	10,000	8,000	8,000	6,000	6,000	N.A.
China	100,000	110,000	110,000	110,000	130,000	126,000
North Korea	130,000	140,000	150,000	160,000	162,000	162,000
Total Communist Countries (Incl. Czech.)	1,320,000	1,383,400	1,435,200	1,536,000	1,595,000	1,625,000

Source: World Bureau of Metal Statistics
N.A. – Not Available

P – Preliminary

TABLE 2.1.10

U.S.S.R. AND OTHER COMMUNIST COUNTRIES SLAB ZINC PRODUCTION

	1970	1971	1972	1973	1974	1975P
	(Tonnes)					
U.S.S.R.	570,000	635,000	650,000	680,000	980,000	960,000
Poland	209,000	220,000	228,300	224,000	240,000	234,000
Bulgaria	76,000	78,000	80,000	84,000	84,000	90,000
East Germany	15,000	15,000	15,000	15,000	15,000	18,000
China	100,000	110,000	120,000	120,000	130,000	126,000
North Korea	90,000	100,000	120,000	120,000	130,000	138,000
Total Communist Countries (Incl. Czech.)	1,120,000	1,219,000	1,273,300	1,314,000	1,654,000	1,632,000

Source: World Bureau of Metal Statistics

P – Preliminary

TABLE 2.1.11

U.S.S.R. AND OTHER COMMUNIST COUNTRIES SLAB ZINC CONSUMPTION

	1970	1971	1972	1973	1974	1975P
	(Tonnes)					
U.S.S.R.	680,000	700,000	760,000	840,000	880,000	888,000
Poland	129,400	140,300	140,000	149,000	160,000	156,000
Bulgaria	28,000	28,000	35,000	40,000	40,000	36,000
East Germany	60,000	60,000	60,000	60,000	60,000	60,000
China	150,000	170,000	170,000	190,000	200,000	204,000
North Korea	10,000	15,000	15,000	20,000	20,000	24,000
Total Communist Countries (Incl. Czech.)	1,159,000	1,219,200	1,294,200	1,420,600	1,488,000	1,493,000

Source: World Bureau of Metal Statistics
P – Preliminary

TABLE 2.1.12

U.S.S.R. IMPORTS AND EXPORTS OF SLAB ZINC, ORE AND CONCENTRATE

	1970	1971	1972	1973	1974E
	Tonnes				
Imports* of Slab Zinc	53,300	49,400	50,600	44,800	
Imports of Zinc Ores and Concentrates	27,000	18,134	27,808	44,722	
Exports of Slab Zinc to Western Countries	24,600	50,200	52,400	70,100	41,200
Total Exports of Slab Zinc	95,100	136,600	133,100	146,400	116,500

Source: World Bureau of Metal Statistics
Metal Statistics: Metallgesellsehaft

*Total imports from Poland, Romania, North Korea and other Countries
E -- Estimate

TABLE 2.1.13

EXPORTS OF SLAB ZINC FROM COMMUNIST BLOCK TO WESTERN COUNTRIES

EXPORTS FROM	1970	1971	1972	1973	1974	1975
	(Tonnes)					
U.S.S.R.	24,600	50,200	52,400	70,100	41,200	
Poland	28,000	28,000	33,200	34,400	24,200	
Bulgaria	28,800	38,300	28,500	17,000	24,800	
East Germany	3,800	3,700	1,700	200	400	
China	-	–	–	–		
North Korea	10,800	33,600	39,500	53,100	29,800	
Total Exports	98,400	156,700	160,800	179,000	124,400	

Source: World Bureau of Metal Statistics

2.2 The United States

2.2.1 CONSUMPTION

The United States is the largest consumer of zinc in the world. Zinc consumption grew at an annual compound rate of 4.2% from 796 000 tonnes in 1960 to a record level of 1 351 000 tonnes in 1973. The U.S. slab zinc consumption is compared in Figure 2.1.1 with other major consumers. Consumption of slab zinc in 1975 decreased 28% to 840 000 tonnes from 1 169 000 tonnes in 1974 (see Table 2.1.1).

As the leading industrial nation in the world, the United States has already adopted all known applications for zinc. However, fluctuations in demand reflect economic activities and population growth. Zinc consumption in the United States averaged in excess of 1 210 000 tonnes during the last decade, ranking it as the fourth most commonly used metal, following steel, aluminum and copper.

The continued decrease in zinc consumption from 1973 to 1975 is largely a reflection of reduced automobile production. The auto industry production rate declined from 12 810 000 units in 1973 to 8 990 000 in 1975, a drop of 30%. This was reflected in the decrease of zinc die-casting use by 49% from 558 000 tonnes in 1973 to 285 000 tonnes in 1975. Regression analysis indicates a positive correlation coefficient of 0.78 between automobile production and zinc consumption in the United States (see Figure 2.2.1).

End-use consumption of zinc in the U.S. is compared, in Table 2.1.2, with patterns in other major sectors of the Free World. Generally, die-casting has been the leading end-user of zinc, accounting for over 40% of the total U.S. zinc consumption. The die-casting sector is largely dependent on the automotive industry, which consumes about 65% of the total die-cast zinc in the U.S.

Galvanizing retains the second position with 35% to 40% of the total U.S. zinc consumption. Consumption in the galvanizing sector suffered a drop of 33% from 475 000 tonnes in 1974 to 318 000 tonnes in 1975. The use of zinc in galvanizing has risen moderately with an annual growth of 3.1% compared to growth rates of 4.9% and 4.6% for brass and die-casting, respectively during the 1960-1973 period. The three segments, die-casting, galvanizing and brass, accounted for 1 040 000 tonnes (or 89% of the total U.S. zinc consumption) in 1974, but declined to 706 000 tonnes (84%) in 1975.

The price of domestically produced Prime Western zinc in the U.S. increased in several steps from the controlled level of 20¢-21¢ per pound prior to December 5, 1973 to a range of 38¢-41¢ per pound at the end of 1975. In January, 1976, the producer price for Prime Western zinc was lowered to 37¢ per pound. The U.S. Producers' price for zinc was raised from 37¢ to 40¢ per pound in August, 1976. In spite of an increase in the European Producers' price from £360 to £390 per tonne the price in dollars declined from 39¢ to 36¢ per pound due to declining exchange rates. In December 1975, European producers began quoting prices on the basis of the U.S. dollar rather than British pound sterling. Detailed discussions on zinc prices and tariffs are covered in Sections 2.5 and 2.7 respectively.

2.2.2 ORE AND CONCENTRATE PRODUCTION

The U.S. mine production of zinc in 1975 was estimated at 430 000 tonnes, a 5% decrease from 453 000 tonnes in 1974. Table 2.2.1 summarizes the ore and concentrate production data for the past decade by geographical regions. The U.S. mine production of recoverable zinc dropped from 522 000 tonnes in 1964 to 430 000 tonnes in 1975, representing a compound rate of decline of 1.8% per annum. Tennessee, Missouri and New York are the major producing states accounting for one-half of the U.S. domestic mine production. However, zinc mines in the U.S. are widely distributed, with zinc being mined in 18 states. Zinc mine production has decreased from its record high of 554 000 tonnes in 1965 to its present level in spite of the continued increase in consumption.

The New Jersey Zinc Company began shipping concentrates from its new Elmwood mine in central Tennessee in January, 1975. In mid-1975, the New Jersey Company reached an agreement with Union Minière SA of Belgium whereby the latter company will acquire a 40% interest in an operating mine near Elmwood. In addition, the two companies will jointly develop three zinc mines and construct a refinery in Tennessee at a total cost of $190 million. Japanese sources recently indicated that four Japanese zinc smelters (Mitsui, Mitsubishi, Sumitomo and Dowa) may join with the New Jersey Zinc Company to develop zinc mines in Tennessee. Callahan Mining Corporation and the New Jersey Zinc Company through a joint-venture began to develop a zinc-copper deposit in north-central Virginia.

Asarco Incorporated closed down its Mascot mill in east Tennessee and brought its new Young mill on stream in the latter-half of 1975. The new mill is capable of processing 7700 tonnes of ore per day, a 20% increase over the replaced Mascot Mill.

2.2.3 SLAB ZINC PRODUCTION

In 1975, slab zinc production in the U.S. dropped 30% to 404 000 tonnes from the 1974 level of 575 000 tonnes, continuing the decline of zinc smelter production since 1969. Historically the United States has been the world's largest producer of slab zinc. However, a combination of economic and environmental factors has resulted in the closure of ten plants between the years 1969 and 1975, accounting for 690 000 annual tonnes of zinc refining capacity (see Table 4.2.1). This loss represents 55% of the U.S.'s operating capacity of 1.25 million tonnes which was available at the end of 1968. This loss of production capacity resulted from the closure of uneconomic, obsolete plants which succumbed to the cost-price squeeze of the early 1970's and the high cost of stringent pollution control standards which were brought into force over those seven years.

Slab zinc production in the U.S. recorded a net drop at an annual compound rate of 2.5% between 1960 and 1973, while all other countries registered annual increases of up to 12.9% (see Table 2.1.4). The U.S. slab zinc production increased from 792 000 tonnes in 1960 to a record high of 1 008 000 tonnes in 1969 before dropping continuously to 404 000 tonnes in 1975. Table 2.2.2 provides a summary of the U.S. slab zinc productive capacity, production and operating rates for the period 1966 to 1975. The productive capacity and slab zinc production are illus-

trated in Figure 2.2.1. Monthly production, shipments and producers' stocks of slab zinc in relation to the price behaviour in the United States are shown in Figure 2.5.3. The critical shortage of productive capacity, and surge in demand for slab zinc in the U.S. to the record high level of 1 360 000 tonnes in 1973 resulted in continued price strengthening to 39¢-40¢ per lb. Table 2.1.4 compares U.S. slab zinc production with other major producers in the Free World.

In 1974 announcements of plans to build two new electrolytic zinc plants represent the first attempts to reverse the trend of declining U.S. domestic slab zinc production capacity. The New Jersey Zinc Company and Union Minière of Belgium have entered into a joint-venture to build a new electrolytic zinc refinery at Clarksville, Tennessee with an annual capacity of 82 000 tonnes; start-up is expected by mid-1979. This will be the first additional new zinc refining capacity in the United States since 1941.

In 1975, Asarco postponed the Stephensport plant in Kentucky which was originally planned for an annual production capacity of 163 000 tonnes. Asarco will continue to re-evaluate the viability of the Stephensport refinery on the basis of a reasonable return on investment.

The National Zinc Company is expected to start up its new 50 000 tonnes per year electrolytic zinc plant in mid-1976, with shipments scheduled for September, 1976. The plant will replace the company's old horizontal retort smelter which is being phased out of operation.

A comparative summary of capital costs for zinc refining complexes is presented in Table 4.2.3 and also shown in Figure 4.2.1.

2.2.4 TRADE AND STOCKPILE

Zinc concentrate supply to the U.S. smelters was about 33% domestic and 67% imported in 1974. Table 2.2.3 gives the breakdown of concentrate supply for the 10 year period 1965 to 1974. Although domestic mine production has remained relatively constant over the past 5 years at about 450 000 tonnes of recoverable zinc, imports of concentrates have decreased dramatically from a high of 546 000 tonnes in 1969 to 218 000 tonnes in 1974. The 1974 imports were considerably higher (i.e. up by 20%) than the 1973 figure of 181 000 tonnes.

Canada is the largest supplier of zinc ores and concentrates to the U.S. In 1974, Canada supplied 147 000 tonnes or 22% of the total zinc concentrate requirement of the U.S. smelters (see Table 2.2.3). The second, third and fourth largest suppliers of zinc concentrates to the U.S. in 1974 were Mexico, Peru and Honduras, respectively.

The demand for slab zinc in excess of refining capacity in the U.S. was largely met by increasing the imports of slab zinc and escalating the quantity of slab zinc released from the U.S. General Services Administration (GSA) stockpile. The GSA zinc stocks were over 1 000 000 tonnes at the end of 1971. With the continued shortage of slab zinc in the U.S., there had been an accelerated release of zinc metal from the government stockpile. The GSA released from its zinc stockpile over 170 000 tonnes in 1972, 280 000 tonnes in 1973 and 241 000 tonnes in 1974. There have been no deliveries from the stockpile since December, 1974. On October 1, 1976, the Federal Preparedness Agency (FPA) announced new stockpile objectives for 93 critical and strategic materials. The objective for zinc was raised from 340 040 tonnes to 1.19 million tonnes. Funds to buy materials for the stockpile must be appropriated by Congress and FPA did not foresee acquisition beginning before October, 1977. A detailed discussion on the U.S. government GSA stockpile is presented in Section 2.6.

The imports of slab zinc to the United States are shown in Figure 2.2.1, in relation to metal production and consumption. The U.S. slab zinc imports reached an historic high of 534 082 tonnes in 1973, and were down only moderately in 1974 to 489 600 tonnes, and further declined to 340 130 tonnes in 1975.

Figure 2·2·1

U.S. SLAB ZINC
PRODUCTION, CONSUMPTION & IMPORTS

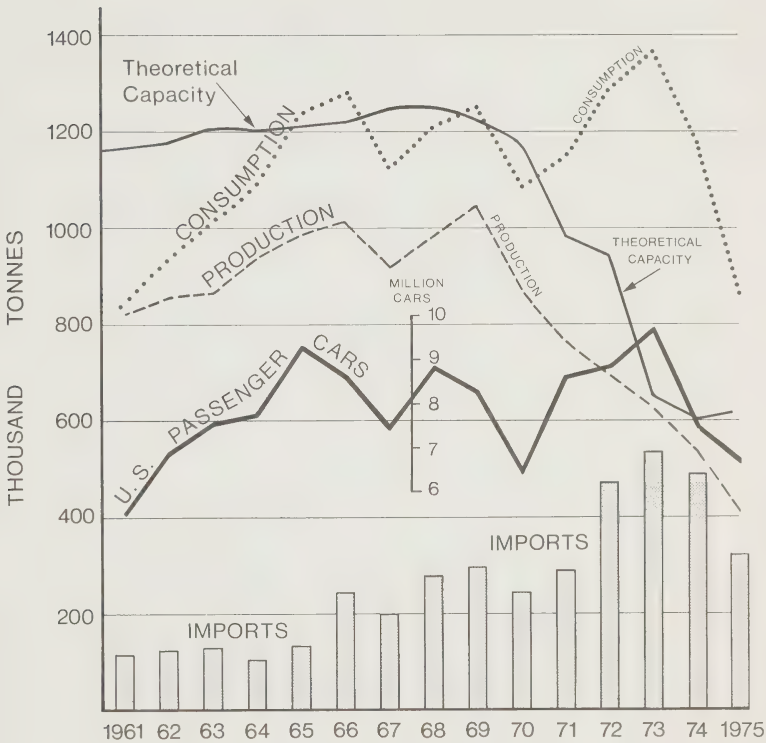


TABLE 2.2.1

THE U.S. MINE PRODUCTION OF RECOVERABLE ZINC (BY GEOGRAPHICAL AREA)

REGION	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974P	1975
	Tonnes											
North Eastern	112,886	123,208	115,006	119,444	115,525	112,926	114,241	114,928	111.593	138,780	145 015	
Southern Appalachian	124,238	129,618	109,573	119,669	129,997	129,945	123,672	123.491	107,513	73,350	89 938	
Central	37,720	45.014	39.858	51.527	50.979	70.549	79.971	64.924	72.733	87.336	94.580	
South Western	126,804	127,061	124,975	111,443	100,756	113,663	109,874	101,248	99.521	87.011	76,829	
North Western	102,198	103,465	104,226	73,854	67,957	65,119	49,410	46,466	40.952	47,680	42.190	
Other	17.663	26,068	25,781	22,487	15.096	9.592	7.395	4,843	1.615	248	4.931	
TOTAL U.S.	521,509	554,434	519,419	498,424	480,310	501,792	484,563	455,900	433.927	434,405	453,485	430.000P

Source: U.S. Zinc Institute Annual Review, 1974
World Metal Statistics, January 1975
U.S. Bureau of Mines

P – Preliminary

TABLE 2.2.2

U.S. SLAB ZINC PRODUCTIVE CAPACITY AND PRODUCTION

YEAR	TOTAL PRODUCTIVE CAPACITY	SLAB ZINC PRODUCTION	OPERATING RATE
	Tonnes		(%)
1966	1,213,200	1,005,000	83%
1967	1,240,300	918,000	74%
1968	1,245,600	999,000	80%
1969	1,224,900	1,008,000	82%
1970	1,175,800	866,000	74%
1971	971,600	769,000	79%
1972	938,700	641,000	68%
1973	648,400	570,000	88%
1974	603,600	575,000	95%
1975P	616,900	404,000	66%

Source: U.S. Department of the Interior Bureau of Mines
American Bureau of Metal Statistics

P – Preliminary

TABLE 2.2.3

SUPPLY OF ORES & CONCENTRATES TO THE U.S.A.

IMPORTED ORES & CONCENTRATES FROM	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
	Tonnes											
Canada	141,870	182,664	247,616	262,527	281,759	333,417	288,478	189,752	122,955	112,724	147,400	
Mexico	94,237	106,462	104,033	108,077	129,104	130,405	116,981	81,507	51,996	30,732	21,937	
Peru	57,027	66,879	70,991	62,930	36,196	51,788	43,579	13,631	13,840	11,953	12,574	
Honduras	6,993	6,156	9,776	8,824	11,756	13,855	17,479	19,515	15,759	5,294	5,654	
Others	23,866	26,151	40,518	42,171	34,118	16,769	10,444	6,401	26 664	19,872	30 200	
TOTAL IMPORTED	323,996	388,311	472,934	484,520	492,938	546,234	476,961	310,806	231,314	180,575	217,763	
Domestic Mine Production	521,509	554,434	519,419	498,424	480,310	501,792	484,563	455,900	433.927	431,687	448.554	
TOTAL ORES & CONCENTRATES	845,505	942,745	992,353	982,944	973,248	1,048,026	961,524	766,706	665.141	612,262	666.317	
	Per Cent											
SUPPLY												
Canada	17%	19%	25%	27%	29%	32%	30%	25%	18%	18%	22%	
Mexico	11%	11%	10%	11%	13%	12%	12%	11%	8%	5%	3%	
Peru	7%	7%	7%	6%	4%	5%	5%	2%	2%	2%	2%	
Honduras	1%	1%	1%	1%	1%	1%	2%	3%	2%	1%	1%	
Other	3%	3%	4%	4%	4%	2%	1%	1%	4%	3%	5%	
Domestic	62%	59%	52%	51%	49%	48%	50%	59%	65%	71%	67%	

Source: U.S. Bureau of Mines Reports IC 8629, 1974, "THE U.S. ZINC INDUSTRY, A HISTORICAL PERSPECTIVE"; WORLD METAL STATISTICS Mineral Industry Surveys, U.S. Bureau of Mines, "ZINC INDUSTRY IN DECEMBER, 1974".

2.3 The Canadian Zinc Industry

Canada ranks as the leading producer of zinc ore and concentrate in the world, exceeding the next largest producers, the USSR and the United States, by a factor of 1.4 and 3, respectively (see Figure 2.1.2). In 1974, Canadian mine production of zinc represented about 28% of the total Free World output, while refined zinc metal output accounted for only 10% of the Free World production. It has been noted that security of land tenure and generous disposition of mineral rights coupled with mineral tax incentives were essential features which attracted foreign risk capital and encouraged mineral exploration and development under virtually no restrictions. These features led to the discovery of large zinc deposits such as Pine Point, Brunswick Mining, Texasgulf, Anvil and Mattabi. Federal tax legislation, until the 1972 Tax Reform, provided substantial direct encouragement to the Canadian mineral industry through liberal income tax allowances for pre-production costs, generous depreciation and depletion allowances, a 3-year tax-free period, and freedom from capital gains tax. Table 2.3.7 summarizes the Canadian federal tax incentives prior to the 1972 Tax-Reform and all subsequent changes until the recent budget in June, 1975. The May 1976 federal budget has proposed an increase in the deductible exploration and development expenses from 30% to 100% for non-principal mining taxpayers.

Provincial governments also provided benefits through tax incentives. However, in recent years there has been a series of changes in the provincial mineral taxation policies. The provincial governments of British Columbia, Saskatchewan, Manitoba, Quebec and Ontario have all increased the tax load on mining operations. These changes have had the marked effect of discouraging exploration activities in certain provinces.

In Ontario, changes were aimed at securing for the people of Ontario higher tax revenues from the extraction of natural resources. A parallel objective has been to ensure that mining companies operating in Ontario remain internationally competitive and enjoy strong incentives to expand not only exploration, but processing facilities as well. The Ontario Mining Tax is a graduated tax on profits derived solely from the mining operation.

Allowances are given for profits attributed to processing operations such as concentrating, smelting and refining. This in itself is a major positive incentive for processing facilities to be built in Ontario.

The recent Ontario Mining Tax revisions can be summarized as follows:

- A graduated tax rate, rising to 40% on mine profits in excess of $40 million;
- Increased depreciation allowance from 15% to 30% on new mining assets;
- Disaggregation provision for profits from new mines;
- Increased processing allowances from 20% to 30% on refining assets and creation of a new category of further processing at 35% on semi-fabricating assets; and
- Increased deductions of up to 100% of exploration and pre-production expenses in computing the mining tax.

In addition, amendments to the Ontario Corporation Tax Act allow the following:

- Retention of automatic depletion allowance at 33 1/3%;
- The 3-year tax exemption has been replaced by provisions for accelerated depreciation.

2.3.1 ORE AND CONCENTRATE PRODUCTION

Canada produced an estimated 1 195 000 tonnes of zinc in 1975, a slight decrease from the 1974 level of 1 237 000 tonnes. The historical data on mined zinc production by province is given in Table 2.3.1, and shown in Figure 2.3.1. The zinc production, exports and consumption data are given in Table 2.3.2.

Canadian annual zinc production has increased from 369 000 tonnes in 1960 to a maximum of 1 227 000 tonnes in 1973, representing a compound growth rate of 10.5% per year. Although an ongoing process of discovery and development led to this growth, a few major developments have accounted for a large part of the increase: the Mattagami and Orchan mines of Quebec in 1963; Brunswick Mining and Smelting's No. 6 and No. 12 mines in New-Brunswick in 1964; Pine Point in the Northwest Territories in 1965; the Kidd Creek mine of Texasgulf Canada (formerly Ecstall Mining Ltd.) in 1967 and the Mattabi Mine in 1972 in Ontario, accounted for approximately 771 000 tonnes per year of new mined zinc by 1973. However, the major growth in zinc ore and concentrate production occurred during the period 1963-1967 (see Figure 2.1.2). Since 1967, growth in production has been at a much slower pace, averaging only 2.5% over the seven-year period 1968-1974.

2.3.2 SLAB ZINC PRODUCTION

Four slab zinc producers operate zinc plants in Canada with a total capacity of 635 000 tonnes of zinc metal per annum in 1975. Annual capacity of individual plants is:

Canadian Electrolytic Zinc Ltd., Quebec	204 000 t/yr.
Hudson Bay Mining and Smelting Ltd., Manitoba	72 000 t/yr.
Cominco Ltd., British Columbia	250 000 t/yr.*
Texasgulf Canada Limited, Ontario	109 000 t/yr.

Tables 2.3.3 and 2.3.4 give capacity and production data for these plants over the period 1964-1975. The production of slab zinc from these plants during 1975 was 427 000 tonnes. In 1974 slab zinc production was 438 000 tonnes, which represented 38% of the total zinc produced as concentrate in Canada (1 160 000 tonnes** in 1974). The

* Roaster capacity has been expanded to 272 000 t/yr.

** Estimated recoverable zinc in ores and concentrates shipped for export plus new refined zinc produced from domestic primary materials.

1975 metal production represented a 20% decrease from the record of 533 000 tonnes of slab zinc in 1973. The decrease in production resulted from severe cut-backs in capacity utilization in the latter half of 1975. The zinc refineries operated at an average of 67% of total capacity during 1975.

2.3.3 STRUCTURE OF THE CANADIAN ZINC INDUSTRY

The Canadian domestic zinc industry is highly integrated vertically to the prime metal stage. The large integrated firms account for all refined zinc output and 80% of the total Canadian zinc concentrate production.

The zinc plant of Cominco, at Trail, B.C. is the world's largest with an annual capacity of 250 000 tonnes of slab zinc. Cominco only produced 147 000 tonnes of zinc in 1974; production was seriously reduced to only 59% of capacity due to an extended strike at the plant. Canadian Pacific Limited, through its wholly owned subsidiary Canadian Pacific Investments holds a 55.5% interest in Cominco Limited.

The Canadian Electrolytic Zinc plant (CEZ) is owned by a group of companies which supply concentrates to the plant. The ownership pattern, on completion of the $61 million plant expansion will be: Noranda Mines Ltd., 22.7%; Mattagami Lake Mines Ltd., 51.7%; Orchan Mines Ltd., 15.8% and Kerr Addison Mines Ltd., 9.8%. Noranda Mines Limited also holds: 34.1% direct and 8.6% indirect interest in Mattagami, 45.1% direct and 5.7% indirect interest in Orchan Mines and 41.3% direct and 2.5% indirect interest in Kerr Addison Mines. Thus through direct and indirect holdings, Noranda holds about 57% control of CEZ and is also the operator of the plant. CEZ's present capacity for slab zinc is 204 000 tonnes per year.

The zinc plant at Hudson Bay Mining and Smelting Company's Flin Flon Manitoba site has a capacity of 72 000 tonnes per year. The plant treats concentrates from 9 company-owned mines in the area, as well as custom concentrates. Production in 1974 totalled 70 800 tonnes of zinc, (98% of capacity). Anglo American Corporation of South Africa, through its Canadian subsidiary Anmercosa Investments Limited holds a 28% controlling interest in Hudson Bay Mining and Smelting Company.

The zinc plant of Texasgulf Canada Ltd., (formerly Ecstall Mining Ltd.) at Timmins, Ontario produced 97 900 tonnes of zinc in 1974, operating at 90% of capacity. The production capacity at present is 109 000 tonnes per year. A proposed expansion of capacity to 136 000 tonnes per year, announced in 1974, has been deferred. The plant treats approximately 50% of Texasgulf Canada Limited's zinc output. Texasgulf Canada Limited is a wholly owned subsidiary of Texasgulf, Inc. of New York, which in turn is 30.2% owned by the Canada Development Corporation.

2.3.4 THE MARKETING OF CANADIAN ZINC

The five largest firms have effective arrangements for marketing 89% of the total Canadian zinc through their direct and indirect participation in production facilities. These companies are: Noranda (32.5%), Texasgulf (21.8%), Cominco (21.4%), Cyprus (9.6%) and Hudson Bay Mining and Smelting (3.7%). In addition, Noranda and Cominco undertake marketing functions for small zinc mine operations.

The four Canadian slab zinc producers consumed about 38% of the concentrates produced in 1974, yielding 438 000 tonnes of slab zinc . The remaining concentrates are marketed abroad, mainly to the U.S., Europe, U.K. and Japan. The exports of ore, concentrate and other zinc products from Canada are shown in Figure 2.3.2. Table 2.3.5 gives the historical data for the export of Canadian zinc in all forms, to the eight major trading countries. Canadian exports of zinc in all forms have grown at a compound rate of 9.2% from 590 000 tonnes in 1964 to 1 299 000 tonnes in 1973. The export of zinc as metal has grown less rapidly, however, from 216 000 tonnes to 422 000 tonnes, a compound rate of growth of 7.7% per year. Total zinc exports decreased to 1 192 000 tonnes in 1974. The decrease is due to a sharp drop in metal exports, from 422 000 tonnes in 1973 to 295 000 tonnes in 1974. Exports of ores and concentrates were up slightly in 1974, by 1.4% to 869 000 tonnes.

The U.S. remains Canada's major customer for zinc exports. Since 1969, the quantity (and proportion) of zinc exported to the U.S. as concentrates has decreased significantly, and the quantity of slab zinc has increased proportionately. In 1969, 348 000 tonnes of zinc concentrates were exported to the U.S.; this decreased to 123 000 tonnes in 1973. This trend reversed itself in 1974 as ore and concentrates exported increased to 164 000 tonnes and slab zinc exported fell to 239 000 tonnes. The total exports to the U.S. in 1974 decreased to 417 000 tonnes.

The change in the proportion of slab zinc and concentrates exported to the U.S. has resulted from the dramatic loss of zinc refining capacity in the U.S. starting in 1969; approximately 55% of U.S. refining capacity was shut down over a five-to-six year period as a result of technical obsolescence and environmental legislation (see Table 4.2.1 for a summary of closures in U.S. refining capacity, 1969 to 1975).

The Canadian zinc supplied as concentrate to Belgium-Luxembourg has grown from 84 700 tonnes in 1963 to 267 000 tonnes in 1973; exports in 1974 decreased to 228 000 tonnes. Exports of slab zinc to Belgium-Luxembourg have been insignificant. West Germany, the Netherlands, and France also receive substantial exports of Canadian zinc concentrates. Great Britain is unique as the only major EEC importer of slab zinc from Canada.

Export of concentrates to Japan have increased steadily over the past decade, growing from 22 000 tonnes in 1964 to 209 000 tonnes in 1973, and 196 000 tonnes in 1974. There have been no significant exports of slab zinc to Japan in this period. The supply of concentrate to Japan is generally through long-term contracts with mines in which Japanese companies have invested capital, either as debt or equity.

2.3.5 CANADIAN ZINC CONSUMPTION

Canada consumed only a small part of its total zinc production. Consumption totalled 149 000 tonnes in 1975, equivalent to 6.8 kg per capita in a population of about 22 million; per capita consumption in 1961 was 3.2 kg. Consumption in the U.S., the world's largest market, is about the same as in Canada on a per capita basis; 6.4 kg per person in 1973 and 5.4 kg per person in 1974. In 1960, U.S. consumption was 4.1 kg per person.

Table 2.3.6 gives the Canadian zinc consumption by end use. Total consumption in 1974 was 110 000 tonnes. Galvanizing is the major use, followed by die-casting. These uses are related to the construction industry, and consumer durables and automobile production, respectively. Zinc usage for galvanizing has increased steadily over the past 5 years, reaching an estimated 59 000 tonnes in 1974; zinc used in die-casting is estimated at 16 000 tonnes in 1974, down from 18 000 tonnes in 1973. The production of copper alloys used about 14 000 tonnes of zinc, and other uses consumed about 21 000 tonnes. Other uses include rolled and ribbon zinc, and zinc oxide.

2.3.6 CANADIAN ZINC CONCENTRATE DEVELOPMENT

A world-wide summary of all new mining projects, that are expected to come on stream from 1973 to 1979 is provided in Table 4.1.1 along with the list of operations which are to be phased out of production. Table 4.1.1 indicates that in Canada a total of 28 000 tonnes of zinc in concentrate form will have been phased out of production between 1973 and 1975, while a total production from new Canadian mines is expected to increase by 306 500 tonnes during 1973-1979 period. This provides a net increase of 278 500 tonnes of zinc in concentrate in Canada.

Developments in the zinc industry of Ontario include: commencement of operation at Sturgeon Lake Mines Ltd. in Northwestern Ontario during the 1974-1975 period, expansion at the Kidd Creek Mine of Texasgulf at Timmins and planned production at the Lyon Lake Division of Mattagami Lake Mines in the Sturgeon Lake area at a rate of 900 tonnes of ore per day by the end of 1977.

There are two or three potential developments of zinc deposits in Northwestern Canada. The project known as "Nanisivik", on Baffin Island, is scheduled to commence production at a rate of 60 000-76 000 tonnes per year in concentrate form during the 1976/77 period. Nanisivik Mines Ltd. is owned 59.5% by Mineral Resources International Ltd., 18% by the Canadian federal government and 11.25% each by Metallgesellschaft AG and Billiton BV. It will be brought into production at an estimated capital cost of $55 million.

Arvik Mines, 75% owned by Cominco, has deferred development of their Polaris mine on Little Cornwallis Island in the Canadian Arctic. Detailed negotiations took place between Arvik Mines and the Canadian federal government regarding conditions and arrangements for development of the 20 million tonne deposit, grading 20% combined zinc and lead, however the conditions required by the government escalated normal Arctic mining risks.

Other potential projects in the North are: Texasgulf's promising discovery about 225 miles north of Yellowknife, Northwest Territories, and Kerr Addison's Grum Joint Venture property near Faro, Yukon Territory.

2.3.7 CANADIAN REFINED ZINC DEVELOPMENT

With the completion of the expansion at Canadian Electrolytic Zinc Limited at Valleyfield, Quebec, Canadian refined zinc production capacity is an estimated 635 000 tonnes of zinc per annum. Cominco's planned expansion will further boost the annual capacity to 661 000 tonnes by the 1977-1978 period. In addition, the Canadian federal government believes that there will be new zinc refining complexes; one in the province of New Brunswick and the other in Northwestern Canada either in the Yukon or in the Northwest Territories. A preliminary feasibility study conducted for the Province of New Brunswick indicated adequate ore reserves and described mining rates which would yield, commencing in 1977, an estimated 384 000 tonnes of zinc concentrates per annum until 1997. This rate of production of concentrate could yield about 176 000 tonnes of slab zinc, which would easily support a zinc refining complex at an initial capacity of 100 000 tonnes of zinc per year. The capital cost of such an electrolytic reduction plant could be in the range of $180 to $200 million. The province appears to have one of the most favourable taxation rates in Canada, and one which has not changed since 1971.

Newfoundland's Premier Frank Moores recently emphasized that the provincial government is actively pursuing the possibility of establishing a zinc smelter-refinery complex in the province. The provincial government is focusing on workable solutions towards making the zinc refining complex feasible and to meet four major criteria: (1) a large source of zinc concentrate, (2) a supply of reliable and competitive energy, (3) an ice-free deep water harbour, and (4) a market for the sulphuric acid by-product of such a zinc refining complex.

Figure 2.3.1

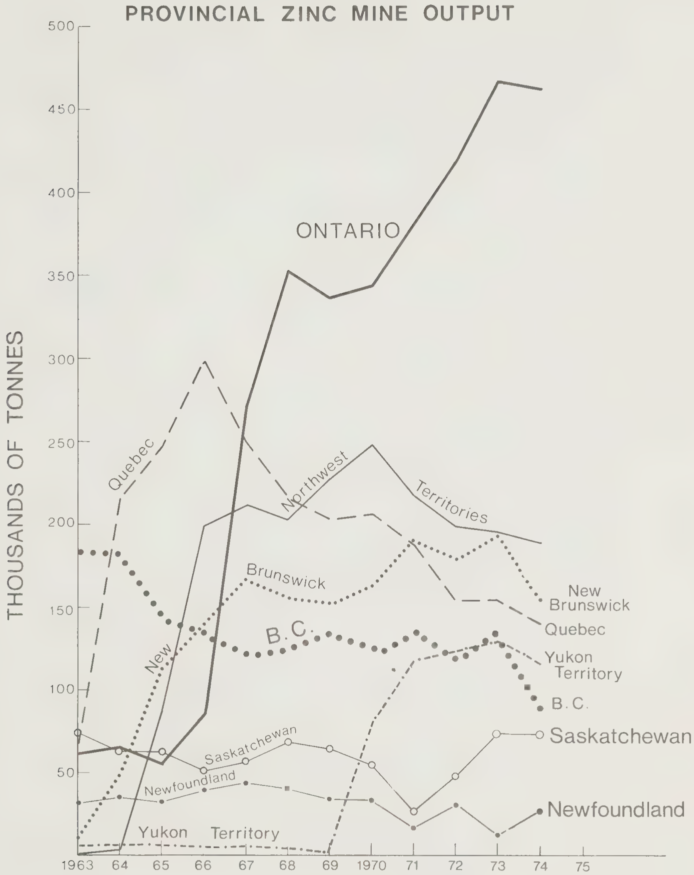

PROVINCIAL ZINC MINE OUTPUT
THOUSANDS OF TONNES
500
450
400
350
300
250
200
150
100
50
1963
64
65
66
67
68
69
1970
71
72
73
74
75
ONTARIO
Quebec
Northwest
Territories
New
Brunswick
B.C.
Saskatchewan
Newfoundland
Yukon Territory
New Brunswick
Quebec
Yukon Territory
B.C.
Saskatchewan
Newfoundland

FIGURE 2 · 3 · 2

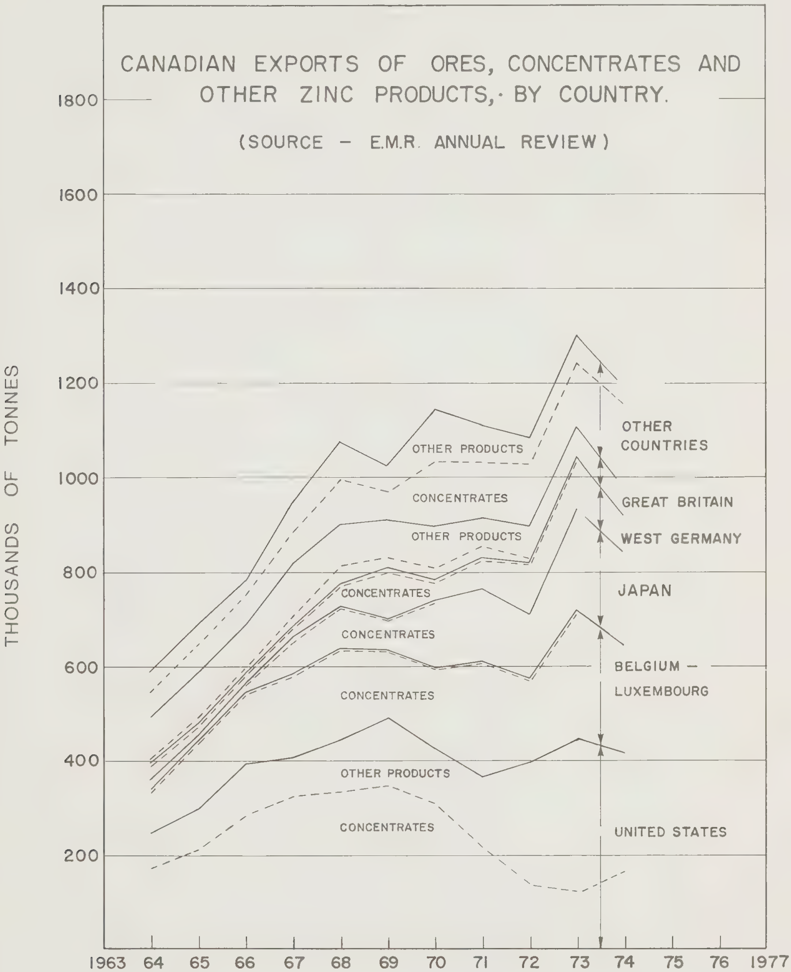

CANADIAN EXPORTS OF ORES, CONCENTRATES AND OTHER ZINC PRODUCTS, BY COUNTRY.
(SOURCE – E.M.R. ANNUAL REVIEW)
THOUSANDS OF TONNES
1800
1600
1400
1200
1000
800
600
400
200
OTHER PRODUCTS
CONCENTRATES
OTHER PRODUCTS
CONCENTRATES
CONCENTRATES
CONCENTRATES
OTHER PRODUCTS
CONCENTRATES
OTHER COUNTRIES
GREAT BRITAIN
WEST GERMANY
JAPAN
BELGIUM – LUXEMBOURG
UNITED STATES
1963
64
65
66
67
68
69
70
71
72
73
74
75
76
1977

TABLE 2.3.1

CANADIAN MINE OUTPUT OF ZINC (2) – 1963-1974

(Tonnes)

	1963(1)	1964(1)	1965(1)	1966(2)	1967(2)	1968(2)	1969(2)	1970(2)	1971(2)	1972(2)	1973(2)	1974(2)P
Ontario	*60,301*	*65,387*	*55,044*	*83,789*	*272,331*	*352,540*	*336,770*	*342,709*	*380,563*	*419,011*	*462,212*	*460,904*
Northwest Terr.	–	3,556	85,902	198,468	211,588	202,975	227,297	248,060	217,153	199,614	196,486	185,959
New Brunswick	9,629	49,326	112,125	138,043	166,648	156,881	152,073	162,488	188,041	178.373	194,602	153,409
Quebec	68,116	214,588	247,558	289,910	250,085	216,179	203,531	206,349	187,841	153,163	154,780	140,156
British Columbia	182,738	181,800	143,641	133,591	122,353	123,882	133,237	125,327	134,599	120,324	134,936	85,082
Yukon Terr.	5,375	5,939	6,009	5,443	5,566	2,819	17,356	79,523	119,036	122,098	130,066	114,465
Manitoba – Sask.	72,314	64,486	62,366	51,730	56,145	69,944	65,514	55,212	26,935	47,991	72,786	72,933
Newfoundland	31,285	35,364	32,829	39,675	44,169	40,522	34,402	33,333	16,071	31,031	11,714	24,415
Nova Scotia	–	540	271	160	134	132	224	160	30	–	18	–
TOTAL	429,758	620,986	745,745	949,800	1,129,202	1,165,873	1,170,404	1,253,107	1,270,269	1,271,605	1,357,602	1,237,324
	(451,039)(2)	(662,196)(2)	(826,389)(2)									

Source: Mineral Year Book – Zinc – Annual Reviews, E.M.R.

(1) Estimated Recoverable Zinc in Ores and Concentrates shipped for Exports Plus
New Refined Zinc produced from Domestic Primary Materials (concentrates, slags, residues etc.)

(2) Zinc content of Ores and Concentrates produced.

P – Preliminary

TABLE 2.3.2

CANADIAN ZINC PRODUCTION, EXPORT AND CONSUMPTION, 1964-1973

(Tonnes)

	PRODUCTION			EXPORTS[2]		CONSUMPTION[3]
	ALL FORMS[1]	REFINED[2]	IN ORES AND CONCENTRATES	REFINED	TOTAL	REFINED PRIMARY ZINC
1964	620,986	306,390	365,692	215,981	581,673	80,281
1965	745,745	325,227	442,207	239,681	681,888	85,091
1966	874,631	347,097	536,453	232,380	768,824	97,117
1967	1,008,304	367,537	667,427	270,028	937,455	97,776
1968	1,051,794	387,125	776,393	289,129	1,065,522	105,215
1969	1,095,550	423,076	729,987	278,866	1,008,853	107,667
1970	1,135,726	413,201	809,256	318,837	1,128,093	95,837
1971	1,133,751	372,533	808,393	283,464	1,091,856	104,720
1972	1,128,678	476,173	695,094	370,416	1,065,510	121,734
1973	1,226,581	532,557	866,433	422,549	1,288,982	129,585
1974	1,159,500	437,932				
1975P	1,052,050	426,941				

Sources: Statistics Canada and Minerals Yearbook

1. New refined zinc produced from domestic primary materials, plus estimated recoverable zinc in ores and concentrates shipped for export
2. Refined zinc produced from domestic and imported ores
3. Refined primary zinc only, reported by consumers

P – Preliminary

TABLE 2.3.3

CANADIAN ZINC PLANT CAPACITY

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975(P)
	(10³ Tonnes)											
Cominco	189,000	210,000	216,000	239,000	239,000	239,000	239,000	239,000	250,000	250,000	250,000	250,000
Hudson Bay M & S	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000
Canadian Electrolytic Zinc	76,000	76,000	127,000	127,000	127,000	127,000	127,000	127,000	132,000	132,000	132,000	204,000
Brunswick M & S	–	–	–	38,000	38,000	38,000	51,000	51,000	–	–	–	
Texasgulf Canada	–	–	–	–	–	–	–	–	109,000	109,000	109,000	109,000
TOTAL	337,000	358,000	415,000	476,000	476,000	476,000	489,000	489,000	563,000	563,000	563,000	635,000

Source: EMR's Annual Reviews

P – Preliminary

TABLE 2.3.4

CANADIAN ZINC PLANT PRODUCTION

(Tonnes)

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Cominco	180,542	193,307	201,306	183,253	190,505	204,168	201,034	191,418	220,448	225,284	147.000	176,721
Hudson Bay M & S	64,422	64,805	66,525	65,373	72,851	72,313	71,325	37,338	69,875	75,190	70.757	59,074
Canadian Electrolytic Zinc	61,426	67,132	79,289	108,410	101,116	117,300	112,583	108,500	131,505	134,943	122,290	106,777
Brunswick M & S	–	–	–	10,470	22,825	29,281*	32,750*	40,615	–	–	–	
Texasgulf Canada	–	–	–	–	–	–	–	–	54,522	97,141	97,885	84.369
TOTAL	306,389	325,244	347,121	367,506	387,297	423,062	417,692	377,872	476,350	532,559	437.932	426,941
% OF CAPACITY	91%	91%	84%	77%	81%	89%	85%	77%	85%	95%	78%	67%

Source: Company Annual Reports

* Includes Non-Refined I.S.F. Zinc Shipped

TABLE 2.3.5

CANADIAN EXPORTS OF ZINC

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974(P)
						(Tonnes)					
TO UNITED STATES:											
– As Concentrate & Ores	171,231	210,102	282,994	326,411	331,554	347,615	307,424	213,549	137,775	122,589	164,019
– As Blocks, Pigs & Slabs	71,271	83,103	105,215	72,412	105,117	133,978	110,049	143,609	247,551	316,124	238,616
– As Scrap, Dross & Ash (Gross Wt)	3,603	5,486	6,673	4,517	3,715	5,733	3,129	1,911	3,225	3,134	11,316
– As Fabricated Material (NES)*	927	595	1,156	2,851	5,338	3,981	4,544	4,943	5,434	6,616	3,341
TOTAL	247,032	299,286	396,038	406,191	445,724	491,307	425,146	364,012	393,985	448,463	417,292
TO BELGIUM–LUXEMBOURG:											
As Concentrate & Ores	84,710	142,179	147,182	172,843	189,055	141,881	171,318	242,685	172,938	267,271	228,395
– As Blocks Pigs & Slabs	5,173	3,357	1,219	4,630	3,332	–	–	1,866	2,192	1,696	
– As Scrap, Dross & Ash (Gross Wt)	2,030	1,709	1,848	1,760	1,137	1,552	901	1,551	1,481	1,845	
– As Fabricated Material (NES)*	–	–	3	11	–	–	5	.	146	136	
TOTAL	91,913	147,245	150,252	179,244	193,524	143,433	172,224	246,102	176,757	270,948	228,395
TO JAPAN:											
– As Concentrate & Ores	22,121	5,293	19,747	66,004	89,513	60,666	135,368	153,924	136,286	208,617	196,172
– As Block, Pigs & Slabs	–	–	446	12,502	–	2,400	7,800	–	–	–	
– As Scrap, Dross & Ash (Gross Wt)	–	107	–	–	–	–	–	–	–		
– As Fabricated Material (NES)*	–	–	–	–	–	–	–	–	53	249	109
TOTAL	22,121	5,400	20,193	78,506	89,513	63,066	143,168	153,924	136,339	208,866	196,281

TABLE 2.3.5

CANADIAN EXPORTS OF ZINC (cont'd)

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974(P)
	(Tonnes)										
TO WEST GERMANY:											
– As Concentrate & Ores	29,300	19,989	17,355	16,627	40,299	100,565	31,844	56,963	107,862	105,169	75,203
– As Blocks, Pigs & Slabs	5,635	7,793	1,683	2,857	7,366	11,890	9,242	8,529	4,187	1,324	
– As Scrap, Dross & Ash (Gross Wt)	–	–	41		-	–	-	–	–	239	743
– As Fabricated Material (NES)*		–	–			–	–				
TOTAL	34,935	27,782	19,079	19,484	47,665	112,546	41,086	65,492	112,049	106,732	75,946
TO BRITAIN:											
– As Concentrate & Ores	6,795	10,652	6,692	22,812	33,849	19,389	26,581	24,244	8,343	–	24,097
– As Block, Pigs & Slabs	88,896	99,398	96,388	113,893	89,757	75,200	86,318	59,112	67,342	64,055	29,861
– As Scrap, Dross & Ash (Gross Wt)	422	-	56	441	394	388	324	191	883	1,086	3,282
– As Fabricated Material (NES)*	627	855	438	333	549	931	1,519	240	349	598	643
TOTAL	96,670	110,905	103,574	137,479	124,549	95,908	114,742	83,787	76,917	65,739	57,883
TO NETHERLANDS:											
– As Concentrate & Ores		723	22,189	24,347	45,672	4,537	76,400	37,869	31,507	48,270	45,963
– As Blocks, Pigs & Slabs	14,092	12,099	2,490	–	1,731	946	–	-			272
– As Scrap, Dross & Ash (Gross Wt)	217	222	-	81	282	199	1,240	1,326	2,136	1,485	423
– As Fabricated Material (NES)*	–			–	–		-	111	–	–	
TOTAL	14,309	13,044	24,679	24,428	47,685	4,736	78,586	39,306	33,643	49,755	46,658
TO FRANCE:											
– As Concentrate & Ores	14,714	15,115	12,685	17,115	15,520	41,102	34,346	42,276	48,793	44,848	55,215
– As Blocks, Pigs & Slabs	829		–	–	–		–	601	1,348	1,169	722
– As Scrap, Dross & Ash (Gross Wt)		-	-				–	–	–	18	230
– As Fabricated Material (NES)*		..	–				-		-		50
TOTAL	15,533	15,115	12,685	17,115	15,520	41,102	34,346	42,877	50,141	46,035	56,217

TABLE 2.3.5

CANADIAN EXPORTS OF ZINC (cont'd)

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974(P)
						(Tonnes)					
TO ITALY:											
– As Concentrate & Ores	–	–	–	–	2	5,015	4,727	9,999	7,134	20,031	28,459
– As Blocks, Pigs & Slabs	3,716	6,426	4,921	6,265	2,703	3,367	8,774	30,022	4,429	3,804	908
– As Scrap, Dross & Ash (Gross Wt)	–	–	–	–	–	–	–	–	–	65	674
– As Fabricated Material (NES)*	–	–	–	-	–	–	–	161	54	164	122
TOTAL	3,716	6,426	4,921	6,265	2,705	8,481	13,625	13,182	11,617	24,064	30,163
TO OTHER COUNTRIES:											
– As Concentrates & Ores	36,817	38,151	27,595	21,262	30,922	9,119	21,242	26,878	44,449	39,703	51,348
– As Blocks, Pigs & Slabs	–	27,504	20,014	–	79,119	52,021	95,705	–	43,364	37,210	24,975
– As Scrap, Dross & Ash (Gross Wt)	–	–	420	–	150	130	1,120	420	1,249	3,120	2,901
– As Fabricated Material (NES)*	141	83	156	54	118	226	992	–	564	267	497
TOTAL	36,958	65,738	48,185	21,316	110,309	61,496	119,059	27,298	89,626	80,301	79,721
TOTAL EXPORTS BY CANADA:											
– As Concentrate & Ores	365,688	442,203	536,439	667,421	776,386	729,981	808,386	808,386	695,088	856,498	868,871
– As Blocks, Pigs & Slabs	215,979	239,678	232,378	270,026	289,126	278,863	318,834	283,461	370,413	422,363	295,354
– As Scrap, Dross & Ash (Gross Wt)	7,066	8,294	9,038	7,458	5,677	8,002	6,714	5,400	8,975	9,148	19,570
– As Fabricated Material (NES)*	1,695	1,533	1,753	3,250	6,005	5,236	7,185	6,438	6,601	7,894	4,762
TOTAL	590,428	691,708	779,608	948,155	1,077,194	1,022,082	1,141,982	1,103,685	1,081,077	1,298,975**	1,192,461**

Source: EMR Annual Review
* NES – Not Elsewhere Stated
** Includes exported Dust & Granules: 3073 tonnes in 1973 and 3905 tonnes in 1974.

TABLE 2.3.6

CANADIAN PRIMARY ZINC CONSUMPTION BY END-USE

END-USE	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
						(Tonnes)					
Copper Alloys	9,222	8,422	12,161	10,396	13,883	14,850	10,921	12,470	13,708	14,504	14,096
Galvanizing	40,019	42,341	42,932	40,630	45,804	42,647	48,684	49,936	54,044	60,891	58,920
Die-Casting	16,298	19,035	23,628	30,190	27,107	29,273	15,848	18,648	22,825	18,359	16,140
Other Products*	14,741	15,292	18,396	16,559	18,420	20,896	20,374	23,211	26,758	23,865	20,812
TOTAL	80,280	85,090	97,116	97,775	105,213	107,666	95,836	104,719	117,334	117,619	109,967
Consumer Stocks at Year-End	10,495	8,201	7,597	8,142	9,104	11,520	9,104	7,833	13,835	11,700	14,271

Source: Zinc – Annual Reviews, E.M.R.
* – Includes rolled and ribbon zinc, zinc oxides
E – Estimate

TABLE 2.3.7

TAX CHANGES – MINING AND PETROLEUM COMPANIES

ITEM	PRE-REFORM	TAX REFORM – 1972	BUDGET – NOVEMBER 18, 1974	BUDGET – JUNE 23, 1975
TAX RATES	Basic rate of 50% on production profits of mining and petroleum corporations, subject to 10% provincial abatement applicable to all corporations.	As for other corporations, basic rate goes down one point annually after 1972 to 46% in 1976. Tax abated 15 additional percentage points after 1976 for mining production profits, together with cancellation of deduction for provincial mining taxes.	Basic corporate rate of 50% established for both mining and petroleum production profits, subject to new resource profit abatement in addition to normal (10%) provincial abatement, effective May 7, 1974. Net federal tax thereby reduced. Abatements: Normal / New / Net Tax Rate Mining: 10% / 15% / 25% Petroleum 1974: 10% / 10% / 10% 1975: 10% / 12% / 28% 1976: 10% / 15% / 25%	Effective January 1, 1976 basic corporate rate of 46% established for both mining and petroleum production profits, subject to normal (10%) provincial tax abatement. New resource profit abatements established by November 18, 1974 Budget to be withdrawn.
PROVINCIAL MINING TAXES ROYALTIES & OTHER LIKE PAYMENTS	Deductible by mining and petroleum corporations.	Royalties and rentals generally deductible. Provincial mining taxes or income related royalties not deductible by mining corporations after 1976.	Effective May 7, 1974, all payments to provinces with respect to the acquisition, ownership or development of a resource property no longer deductible by resource corporations in computing taxable income.	Non-deductibility of payments to provinces to continue, but resource allowance introduced, effective January 1, 1976, in recognition of payments. Resource allowance deduction will be 25% of resource productions profits calculated after operating expenses and capital cost allowance but before the deduction of interest expense, exploration and development and earned depletion.

TABLE 2.3.7 (cont'd)

TAX CHANGES – MINING AND PETROLEUM COMPANIES

ITEM	PRE-REFORM	TAX REFORM – 1972	BUDGET – NOVEMBER 18, 1974	BUDGET – JUNE 23, 1975
OPERATORS' DEPLETION	Automatic depletion allowances permitted reduction of production profits by 33 1/3%.	Automatic depletion to continue to end of 1976. Thereafter, depletion "earned" by eligible expenditures on exploration and development and certain capital expenditures, deductible at maximum rate of 33 1/3 % of production profits.	Earned depletion system to commence effective May 7, 1974. Rate of claiming reduced to 25% of annual production profits from 33 1/3%.	No change from November 18, 1974 Budget provisions. Earned depletion deduction to be claimed after deduction of 25% resource allowance, interest, and exploration and development.
		$3 of eligible expenditures after November 7, 1969 earn $1 of depletion.	Rate of earning remained at $1 of depletion for each $3 of eligible expenditure.	
NON-OPERATORS' DEPLETION	Depletion allowance of 25%.	Rate of 25% continues to end of 1976. Thereafter, such rentals and royalties treated as production income eligible for 33 1/3% earned depletion.	Effective May 7, 1974 rentals and royalties treated as production income eligible for earned depletion but annual rate of claiming reduced to 25% from 33 1/3%.	Effective January 1, 1976 new 25% resource allowance to apply to individuals as well as corporations with earned depletion rate of claiming at 25% per year after deduction of resource allowance interest and exploration and development.

TABLE 2.3.7 (cont'd)

TAX CHANGES – MINING AND PETROLEUM COMPANIES

ITEM	PRE-REFORM	TAX REFORM – 1972	BUDGET – NOVEMBER 18, 1974	BUDGET – JUNE 23, 1975
CANADIAN EXPLORATION AND DEVELOPMENT EXPENSES:				
Principal business taxpayers	Deductible to extent of income in year or any subsequent year.	No change	Exploration expenditures deductible at 100% or to extent of income. Development expenses, including acquisition cost of mineral properties, incurred after May 6, 1974, deductible at rate of 30% of unclaimed balance.	No change from November 18, 1974 Budget provisions.
Non-principal business taxpayers	Deductible only from mining and petroleum income.	Deductible from income from resource or 20% of unclaimed balance, whichever greater.	Expenditures incurred after May 6, 1974 deductible at rate of 30% of unclaimed balance.	No change from November 18, 1974 Budget provisions.
THREE-YEAR EXEMPTION FROM INCOME TAXATION	Available to eligible new mines.	Exemption terminated at end of 1973. Accelerated capital cost allowance available for new mines and major expansions.	No change	No change

TABLE 2.3.7 (cont'd)

TAX CHANGES – MINING AND PETROLEUM COMPANIES

ITEM	PRE-REFORM	TAX REFORM – 1972	BUDGET – NOVEMBER 18, 1974	BUDGET – JUNE 23, 1975
CAPITAL COST ALLOWANCE (DEPRECIATION)	Buildings, mining machinery and equipment at rate of 30% declining balance.	Accelerated depreciation on assets related to a new mine, to the extent of income from the new mine (100%). Also applies to certain assets related to expansion of an existing mine where the milling capacity is increased by at least 25%.	No change	No change
INVESTMENT TAX CREDIT	NIL	NIL	NIL	Tax liability may be reduced by tax credit against federal income tax with credit developed at 5% of investment on specified items made in period between June 23, 1975 and July 1, 1977. Credit effective June 24, 1975.

2.4 The Ontario Zinc Industry

2.4.1 ORE AND CONCENTRATE PRODUCTION

In 1973, Ontario's mined zinc production of 462 000 tonnes exceeded that of any other Free World country, and represented 10% of the total Free World production (see Figure 2.1.2). At present Ontario produces approximately as much mined zinc as either the United States, Australia or Peru, the world's leading zinc producers after Canada and the USSR. Ontario is also Canada's leading zinc-producing province, with 34% of Canada's total output (see Figure 2.3.1).

Preliminary estimates indicate that Ontario produced 374 000 tonnes in 1975 compared with 453 000 tonnes of mined zinc in 1974. The province's zinc production statistics are given in Table 2.4.1, and the milling capacities of the producing mines are given in Table 2.4.2.

2.4.2 STRUCTURE OF ONTARIO'S ZINC INDUSTRY

Although there are six producing mines and 6 separate mining companies, the Ontario zinc industry is dominated by only two companies; Texasgulf which produces 60% of Ontario's mined zinc, and Noranda which controls directly or indirectly 35% of Ontario's zinc.

The Kidd Creek Mine is operated by Texasgulf Canada Ltd., a wholly-owned subsidiary of Texasgulf Inc. of New York. The Canada Development Corporation (CDC) holds 30.2% interest in Texasgulf Inc. The CDC was launched by, and originally owned by the Government of Canada, with the intent that it would ultimately operate in the private sector. After the public share offering in 1975 about 32% of the voting rights were held directly by Canadian investors.

Through direct and indirect corporate control, Noranda Mines Limited exerts a powerful influence in the Ontario zinc mining industry. Noranda owns the Geco mine which it acquired in 1964, and also holds 25.6% ownership of Mattabi Mines indirectly through its 42.7% direct and indirect interest in Mattagami Lake Mines. The concentrate from Willroy and Willecho Mines is marketed by the Noranda Sales Corporation under a contractual sales agreement. Thus through direct and indirect ownership, and via sales contracts, Noranda controls the disposition of 35% of Ontario's zinc mine production.

2.4.3 ZINC PRODUCERS IN ONTARIO

Ontario has six producing mines; the following outlines give an individual description of each mine and a brief summary of its production.

KIDD CREEK MINE

Texasgulf Canada Ltd., the wholly-owned subsidiary of Texasgulf Inc., owns and operates the Kidd Creek Mine in Timmins, Ontario. *The Kidd Creek Mine has in recent years been the world's largest single source of zinc.* The mine also yields substantial quantities of silver and copper as well as lead, cadmium and tin. Production details are listed in Table 2.4.4.

Texasgulf discovered the Kidd Creek sulphide orebody in 1963 and brought an open pit mine into production in 1966. The underground mining, crushing and ore handling facilities became operational in 1973 from a 914 metres shaft. Production from the open pit is gradually being phased out and it will probably be closed by 1977. An expansion of the underground production facilities is scheduled for completion in 1978. The Company is sinking a shaft to the 1615 metres level to operate a second underground mine at Kidd Creek. The new mine and the addition of a fourth circuit to the concentrator, will facilitate a 35% increase in production capacity to 4.5 million tonnes of ore per year. The total capital cost for the new mine and concentrator expansion is currently (1975) estimated at $140 million.

The company is building a copper smelter and refinery at Kidd Creek for start-up in 1978 and additional facilities will be built to recover silver, selenium and some gold from copper refinery slimes. Refined copper production is expected to increase from an initial level of 59 000 tonnes per year to 118 000 tonnes per year. These copper smelting and refining facilities are expected to cost over $250 million.

Ore reserves at the Kidd Creek Mine are estimated at 78 million tonnes to a depth of 853 metres at a grade of 5.9% zinc, 2.7% copper, 0.21% lead and 79 grams of silver per tonne. This will assure a minimum life of 18 years. However, more drilling will be carried out below the 853 metre level on completion of the 1615 metre shaft. Results to date indicate the presence of sufficient ore to support the operation of the deeper mine for several more years. Based on production and drilling data the copper content of the ore increases with depth, while both zinc and silver decrease. The deepest ore yet intersected is at approximately 1524 metres, but the ultimate depth and dimension of the orebody are still not known, nor has it been fully defined laterally, except in the area of the open-pit and certain levels above 853 metres.

The concentrator treats two different types of ore in three individual circuits to recover copper, lead and zinc concentrates. Another circuit recovers pyrite and tin concentrates from the combined tailings of the three main circuits. The plant produces seven concentrates: high-silver copper, low-silver copper, lead, low-silver zinc, high-silver zinc, pyrite and tin. At present pyrite has no value and is stockpiled for future use.

About half of the zinc concentrates and all of the lead and tin concentrates are sold to third parties. The zinc concentrates are shipped by rail from Timmins to smelters and refiners in the United States and through the port at Quebec City to Europe and Japan. The lead concentrates are sold in the U.S. and tin concentrates are sold in the U.K. Generally these concentrates are sold under one to three year contracts which provide for payment according to the chemical analysis and current market prices for the metal contained. The remaining zinc concentrates are processed in the Company's own zinc plant at Timmins which commenced operation in 1972 with an annual design capacity of 109 000 tonnes of zinc metal. Zinc metal is sold by Texasgulf Inc., largely to customers in the U.S. Cadmium is sold to various customers in North America and Europe.

The copper and copper-silver concentrates are shipped to a Canadian smelting and refining company in Quebec for processing under a "tolling" arrangement which expires in

late 1976. The copper and silver recovered are sold by Texasgulf Inc., primarily in Canada and the United States. About 20% of the copper is sold in Europe.

GECO MINE

The Geco Mine started production in 1957 with a concentrator capacity of 3000 tonnes per day. The capacity was last increased in 1970 to 4640 tonnes per day. The mine and mill provide direct employment for 600 people. The mine was acquired by Noranda Mines Limited in 1964 and is now operated as a wholly-owned division of the company. The mine produces zinc as well as copper concentrates, all of which are being refined in Canada. Table 2.4.5 summarizes the production data for the 1972-75 period.

Most of the Geco Mine's zinc concentrate output is treated in the Canadian Electrolytic Zinc (CEZ) refinery near Valleyfield, Quebec. CEZ is managed by Noranda Mines Limited and is owned by a group of companies which supply concentrates to the plant (details are presented in Section 2.3.3).

Ore reserves at the Geco Mine were reported at the end of 1975 to be 25 500 000 tonnes of ore containing average grades of 1.87% copper, 3.62% zinc, small amounts of lead and 52 grams of silver per tonne. This is adequate to provide continuous feed to the concentrator for 16 years.

MATTABI MINE

The Mattabi Mine commenced commercial production in August 1972 from a new open pit operation near Ignace, northwestern Ontario. The mine-concentrator complex was brought on stream at its design capacity of 2720 tonnes of ore per day and at a capital cost of $44 million.

The Mattabi Mine provides gainful employment for 300 people. Production data are summarized in Table 2.4.6. Zinc concentrates are shipped to the United States, to Quebec City for export overseas and to Canadian Electrolytic Zinc at Valleyfield, Quebec. All the copper concentrates are shipped to the smelter of Noranda Mines Limited at Noranda, Quebec.

Plans are continuing for the underground development and mining of the orebody, since the open-pit mining will be phased out by the end of 1978. Ore reserves at the end of 1975 were estimated at 9 million tonnes with average grades of 6.7% zinc, 0.74% copper, 0.70% lead and 90 grams of silver per tonne. This ore reserve base is adequate for supplying the feed to the concentrator for 9 years.

STURGEON LAKE MINE

The zinc-copper-silver mine was brought into production in October, 1974 and commercial production began in February, 1975 at a rate of 1090 tonnes of ore per day.

Sturgeon Lake Mines Limited was formed in 1971 to acquire and bring into production the 77-claim NBU property in the Sturgeon Lake area of north-western Ontario. Falconbridge Copper Limited owns 67% of this company and NBU Mines Limited retains 33% interest. Exploration in 1970-71 discovered the main orebody which extends to the north into the adjoining claims of Mattagami Lake Mines Limited. In December, 1972, the company purchased Mattagami Lake Mines' portion of the orebody to a depth of 107 metres for $3 million. This will permit mining of the orebody by a single open pit.

The total capital costs for the open-pit mine and concentrator were estimated at $19-20 million. Ore reserves at the end of 1975 were estimated at 1 637 000 tonnes with average grades of 10.28% zinc, 2.8% copper, 1.36% lead and 194 grams of silver per tonne of ore. This will provide a continuous operating life of 5 years. During 1975 the mine produced 394 000 tonnes of ore and yielded 22 456 tonnes of zinc in concentrates, 7223 tonnes of copper in concentrates and 33.5 million grams of silver.

WILLROY AND WILLECHO MINES

The Willroy Mine ushered in Ontario's first zinc production in 1957 when its 1100 tonnes per day mill began operation. Between 1964 and 1966 the milling capacity was increased to 1550 tonnes per day. In 1974, the mine produced 9400 tonnes of zinc contained in concentrate. The Willroy mine is now close to exhaustion of its ore reserves and its present life is expected to be about two years. An active exploration program is underway in an attempt to extend the life of the mine. The ore in the Willroy shaft region is becoming uneconomic, and ore from the Willecho shaft region is being used to supply the mill.

The ore yields copper and lead concentrates as well as zinc. Table 2.4.7 summarizes production data for the 1972-1975 period. Zinc concentrates are sent to the U.S. for treatment. Employment in the mine and mill is 225.

Reserves were reported at 529 000 tonnes as of the end of 1975, with a grade of 3.91% zinc, 0.47% copper, 0.16% lead and 53 grams of silver per tonne.

SOUTH BAY MINE

The South Bay Mine of Selco Mining Corporation was brought into production in the first half of 1971, with a milling capacity of 450 tonnes per day and reserves of 528 000 tonnes grading 14.4% zinc, 2.3% copper and 129 grams of silver per tonne. In 1974 the company reported significant new ore zones, and started a $2.5 million development program which includes deepening the shaft to a depth of 640 metres. Two years ago the ore reserves were sufficient for only three more years, however, the new ore zones will permit mining to continue for several years beyond this. As of March 31, 1975, reserves (proven and probable) above the 274 metre level were 293 000 tonnes, grading 1.9% copper, 12.45% zinc and 104 grams of silver per tonne. The mine produced 18 400 tonnes of zinc in concentrate in 1974; production data from 1972 onwards are given in Table 2.4.8. The mine and mill employed 175 people in 1974, an increase of 25 over 1973 employment figures.

THE LYON LAKE DIVISION— MATTAGAMI LAKE MINES LIMITED

At the Lyon Lake property, drilling to the end of 1974 indicated five orebodies. Formerly known as the Lyon Lake Project, claim Group 23, this 69-claim property lies immediately east of Abitibi Block 7, immediately north of Sturgeon Lake Mines Limited and about 8 kilometres from the Mattabi Mine. It is planned to develop the presently known orebodies from a vertical shaft, extending to a depth of 474 metres. Production is expected to commence at a rate of 900 tonnes of ore per day by the end of 1977. Ore reserves, as recalculated during the first quarter of 1975, are 3.7 million tonnes grading 6.66% zinc, 1.15% copper and 116 grams of silver per tonne with minor values of lead and gold.

2.4.4 REFINED ZINC PRODUCTION

Texasgulf Canada Limited operates Ontario's only zinc refining complex at its integrated operation at Timmins, Ontario. The plant has a capacity of 109 000 tonnes of refined zinc per year, representing about one-sixth of Canada's total zinc production capacity. Texasgulf produced 84 000 tonnes of zinc metal in 1975, consuming about 50% of the zinc concentrates produced from the Kidd Creek mine. The metal production at Timmins represents about 25% of the total mined zinc output of Ontario. A further quantity of Ontario's mined zinc is processed to metal within Canada at CEZ's zinc plant at Valleyfield, Quebec. The concentrates from Geco and some of Mattabi's output are treated there, representing about 15% of Ontario output. The remaining 60% is exported outside Canada for treatment, mainly to refineries in the U.S., Europe and Japan.

Table 2.4.3 shows zinc metal and zinc concentrate production for Ontario in relation to total Canadian production.

2.4.5 THE DEVELOPMENT OF ZINC MINING IN ONTARIO

In 1958 two major zinc mines, Geco Mines Ltd. and Willroy Mines Ltd., had their first full year of production. Geco produced 17 900 tonnes of zinc in concentrate, and shipped the concentrate to the U.S. for smelting and refining. Willroy's concentrate (containing 31 300 tonnes of zinc) was shipped to smelters in the U.S. and Belgium. Willroy's output is currently marketed by the Noranda Sales Corporation. By 1961, zinc production from these two had increased to 47 100 tonnes, and Geco entered into an agreement to participate in Canadian Electrolytic Zinc for start-up in 1963.

In 1963, Kam Kotia started to extract zinc concentrate from its ores and in 1964 produced 1500 tonnes of contained zinc. Over the next 5 years Kam Kotia's production increased, reaching 14 200 tonnes per year in 1968 and 1969, then declined steadily until the mine closed at the end of 1972.

In 1964, the discovery of the Kidd Creek orebody was announced by Texasgulf, with production scheduled for late 1966. In 1965 Willecho Mines Limited started regular shipments of ore to the Willroy Mill. In 1966, Canadian Jamieson Mines Ltd. and Zenmac Mines Ltd. started production at annual rates of about 4000 tonnes and 7000 tonnes of zinc per year respectively. The Kidd Creek Mine also started production in 1966 and in 1967 produced 204 000 tonnes of zinc. The concentrates were shipped to custom smelters in the U.S., Europe and Japan. By 1967, seven mines were in operation, producing 272 000 tonnes of contained zinc, which grew to 434 000 tonnes by 1972. Geco's output (normally about 50 000 tonnes per year) was processed at CEZ, and about one half of Texasgulf's output was processed to zinc metal at the new zinc plant at Timmins, Ontario.

In 1973 Mattabi Mines Limited, another major zinc producer, came into full production at 103 000 tonnes per year. Mattabi is jointly owned 60% by Mattagami Lake Mines and 40% by Abitibi Paper Company.

In late 1974 Sturgeon Lake Mines started production and achieved its commercial production rate of 1090 tonnes per day in February 1975.

Figure 2.4.1
ONTARIO ZINC PRODUCTION
IN RELATION TO
CANADA AND WORLD

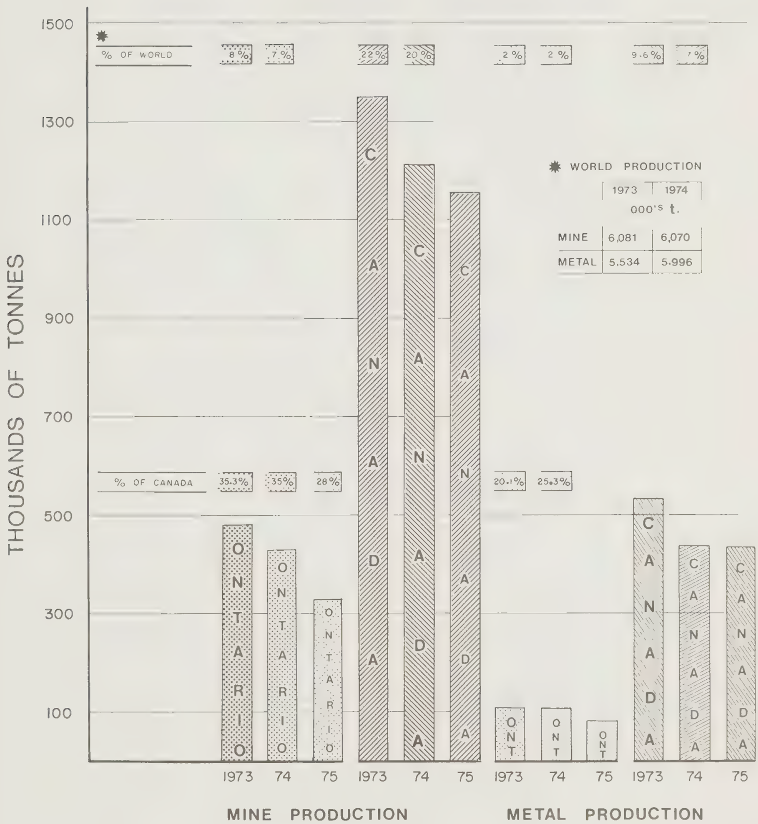


Figure 2.4.2

ZINC MINES OF ONTARIO

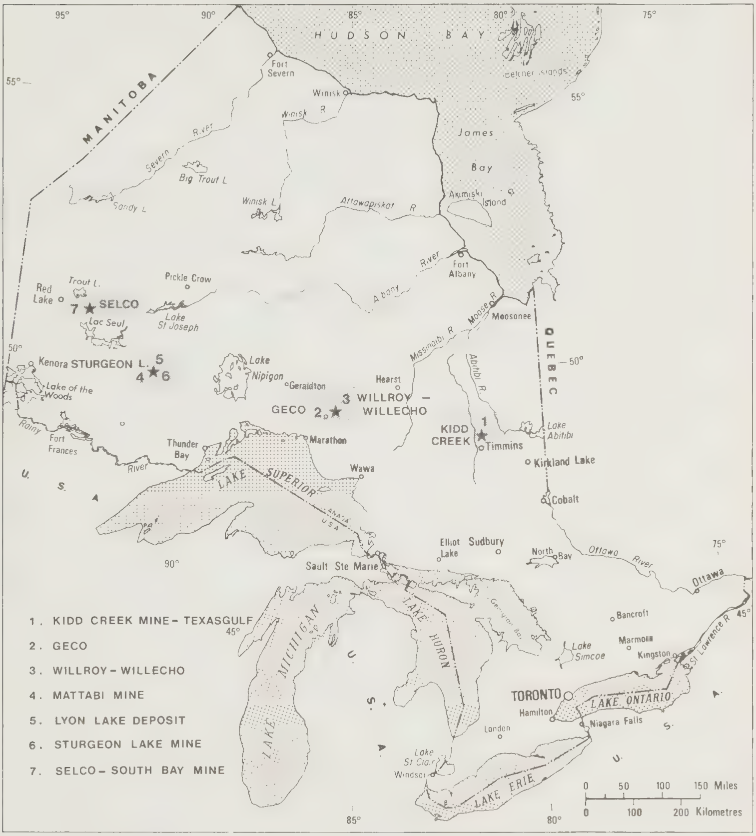


TABLE 2.4.1

ZINC MINE PRODUCTION IN ONTARIO
(Contained Zinc in Concentrate, Tonnes)

MINE	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974P	1975
Geco Div. Noranda, Manitouwadge	25,730	38,147	44,776	54,004	51,383	38,900	41,842	36,738	49,671	46,666	43,637	72,575	55,842	49,320	65,859	
Willroy Mines Ltd., Manitouwadge	24,948	20,805	19,298	10,616	13,928	10,128	4,853	4,111	2,639	12,374	13,982	10,620	9,968	7,928	9,445	
Kam Kotia Mines Ltd., Timmins	–	–	–	21	1,506	3,523	4,666	6,087	14,197	14,175	8,471	7,326	5,342	(Closed, Dec. 30 1972)		
Willecho Mines Ltd., Manitouwadge					(Start-up Mar. 1965)	9,553	9,979	8,888	8,486	(Included in Willroy M.L.)						
Canadian Jamieson M.L., Timmins						(Start-up Apr. 1966)	3,042	4,225	4,866	5,943	4,087	269	(Closed Feb. 1971)			
Texasgulf Canada Ltd., Timmins						(Start-up Nov. 1966)	N.A.	204,117	277,369	279,309	275,817	288,050	299,379	295,641	273,795	
Zenmac Metal Mines, Ltd., Schreiber						(Start-up Jan. 1966)	5,697	7,834	6,793	3,913	859	(Closed Apr. 1970)				
Big Nama Creek Mines Ltd., Manitouwadge								(Start-up, 1968)	385	1,739	2,476	N.A.	(Closed Sept. 1971)			
Jameland Mines Ltd., Timmins									(Start-up, 1969)	N.A.	N.A.	1,507	2,568	(Closed Dec. 1972)		
Selco Mining Corp. South Bay Div. Uchi Lake											(Start-up July 1971)	13,466	20,624	20,922	18,593	
Mattabi Mines Ltd., Sturgeon Lake												(Start-up July 1972)	40,203	103,176	81,427	
Lynx-Canada Expl. Long Lake Mine													(Start-up Mar. 1973)	4,228	4,018	(Closed Dec. 1974)
Falconbridge Copper Mines Ltd., Sturgeon Lake Mine														(Start-up Sept. 1974)	3,870	
TOTAL	50,678	58,952	64,074	64,641	66,817	62,104	70,079	272,000	264,406	264,119	249,329	393,813	433,926	476,987	452,989	

Source: EMR's Annual Reviews

TABLE 2.4.2

ZINC MINE MILL CAPACITY IN ONTARIO

(Tonnes)

MINE	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Geco Div., Noranda Manitouwadge	3,000	3,000	3,000	3,000	3,000	3,000	3,350	3,350	3,650	3,650	4,450	4,550	4,700	4,550	4,550	4,550		
Willroy Mines Ltd., Manitouwadge	1,100	1,100	1,100	1,100	1,350	1,350	1,550	1,550	1,550	1,550	1,550	1,450	1,550	1,550	1,550	1,550		
Kam Kotia Mines Ltd., Timmins	–	–	–	1,450	1,350	1,600	1,600	1,800	2,250	2,350	2,250	2,250	2,250	(Closed)	–	–		
Willecho Mines Ltd., Manitouwadge	–	–	–	–	(ORE MILLED AT WILLROY MINES LTD.)													
Canadian Jamieson M.L., Timmins	–	–	–	–	–	–	400	400	400	400	500	500	(Closed)	–	–			
Texasgulf Canada Ltd., Timmins	–	–	–	–	–	–	8,200	8,200	8,200	8,200	8,200	9,100	9,100	9,100	9,100	9,100		
Zenmac Metal Mines, Ltd., Schreiber	–	–	–	–	–	–	140	150	180	180	180	(Closed)	–	–	–			
Big Nama Creek Mines Ltd., Manitouwadge	–	–	–	–	–	–	–	–	N.A.	300	N.A.	N.A.	(Closed)	–	–			
Jameland Mines Ltd., Timmins	–	–	–	–	–	–	–	–	–	650	N.A.	N.A.	N.A.	(Closed)	–			
Selco Mining Corp. South Bay Div. Uchi Lake	–	–	–	–	–	–	–	–	–	–	–	450	450	450	450	450		
Mattabi Mines Ltd., Sturgeon Lake	–	–	–	–	–	–	–	–	–	–	–	–	2,700	2,700	2,700	2,700		
Lynx-Canada Expl., Long Lake Mine	–	–	–	–	–	–	–	–	–	–	–	–	–	100	100	(Closed Dec. 1974)		
Falconbridge Copper Mines Ltd., Sturgeon Lake Mine	–	–	–	–	–	–	–	–	–	–	–	–	–	–	750	1,100		
TOTAL	4,100	4,100	4,100	5,550	5,700	5,950	15,240	15.450	16,230	17,280	17,230	18,300	20,750	18,450	19,200	19,450		

Source: EMR's Annual Reviews

TABLE 2.4.3

ONTARIO ZINC PRODUCTION

(Tonnes)

	MINED RECOVERABLE ZINC[1] PRODUCTION			REFINED ZINC PRODUCTION			
YEAR	ONTARIO	CANADA	ONTARIO AS % OF CANADA	ONTARIO	ONTARIO AS % OF TOTAL ONTARIO PRODUCTION	CANADA	CANADA AS % OF TOTAL CANADIAN PRODUCTION
1963	60,301	429,753	14.0%			257,660	60.0%
1964	65,386	620,980	10.5%			306,387	49.3%
1965	55,043	745,738	7.4%			325,224	43.6%
1966	74,747	874,622	8.5%			347,093	39.7%
1967	259,937	1,008,293	25.8%			367,533	36.5%
1968	314,573	1,051,783	29.9%			387,121	36.8%
1969	326,846	1,095,539	29.8%			423,072	38.6%
1970	308,662	1,135,715	27.2%			413,196	36.4%
1971	331,780	1,133,740	29.3%			372,529	32.9%
1972	358,239	1,128,667	31.7%	54,522	15.2%	476,168	42.2%
1973	414,007	1,226,581	33.8%	97,159	23.5%	532,552	43.4%
1974	422,077 P	1,159,508 P	36.4%	97,885	23.2%	426,271	37.8%
1975 P	337,000 E	1,052,050 E	31.1%	84,369	25.0%	426,941	39.4%

Source: Zinc – Annual Reviews – E.M.R.

P – Preliminary
E – Estimate

(1) Estimated recoverable zinc in Ores and Concentrates shipped for export plus new refined zinc produced from domestic primary materials (concentrates, slag, residues, etc.)

TABLE 2.4.4

KIDD CREEK MINE PRODUCTION

		1970	1971	1972	1973	1974	1975
Ore Mined and Processed	(10^3 Tonnes)	3,253	3,342	3,291	3,275	3,375	3,293
Concentrate Produced							
(1) 52% Zinc	(10^3 Tonnes)	529	536	560	535	527	458
(2) 25% Copper	(10^3 Tonnes)	156	165	165	187	210	208
(3) Copper-Silver	(10^3 Tonnes)	–	–	–	1	10	9
(4) Tin	(10^3 Tonnes)	–	–	–	0.5	0.2	0.3
Silver in Concentrates	(Million ounces)	13	12.9	13	10.7	10.5	9.2
Zinc Metal	(10^3 Tonnes)	–	–	55	97	98	84
Cadmium Metal	(000's Pounds)	–	–	173	1,133	782	940
Number of Employees		–	–	–	1,575	1,675	1,927

Source: Texasgulf Inc.,
Preliminary Prospectus, November, 1975
Annual Report, 1975

TABLE 2.4.5

GECO MINE PRODUCTION

	1972	1973	1974	1975
		Tonnes		
Ore Mined and treated Contained metal:	1,646,568	1,328,141	1,657,454	1,450,588
Copper (Concentrate)	32,659	20,775	26,490	24,857
Zinc (Concentrate)	55,611	49,442	64,411	40,370
Lead (Concentrate)	1,905	1,452	1,542	816
		Ounces		
Contained Silver	2,530,000	1,684,000	2,058,000	1,680,000
Number of Employees	600	600	600	641

Source: Noranda Mines Limited
Annual Reports

TABLE 2.4.6

MATTABI MINE PRODUCTION

		1972	1973	1974	1975
Ore mined and processed	(10^3 Tonnes)	400	1,009	1,033	975
Concentrate Produced					
(1) 55% Zinc	(10^3 Tonnes)	73	184	150	113
(2) 25% Copper	(10^3 Tonnes)	16	35	31	32
(3) Silver in concentrates	(000's ounces)	1,514	4,182	3,409	2.123
Number of Employees			270	300	291

Source: Annual Reports – Mattagami Lake Mines Limited

TABLE 2.4.7

WILLROY MINE PRODUCTION

	1972	1973	1974	1975
		Tonnes		
Ore Milled	391,057	390,530	357,570	296,971
Grade % Copper	1.10	0.98	0.42	0.42
% Zinc	3.27	2.74	3.06	3.82
Silver oz/S.T.	1.41	1.42	1.38	1.56
Reserves	849,000	649,395	651,373	528,666

Disposal of Concentrates:

Copper concentrates are shipped to Noranda, Quebec, on a contract which expires October 1, 1976, lead and zinc concentrates are handled via a contract with Noranda Sales Corp. Ltd. which expires January 1, 1977; lead concentrates are shipped to Cominco, Trail, B.C.; zinc concentrates are shipped to the U.S.

Source: Annual Reports, Willroy Mines Limited

TABLE 2.4.8

SOUTH BAY MINES (Selco Mining Corp.)

	1972/3	1973/4	1974/5
		Tonnes	
Ore Milled	169,400	172,240	172,390
Zinc contained in concentrate	22,301	18,771	18,848
Copper contained in concentrate	2,039	2,666	2,840 S.T.
Silver contained in concentrate (oz/S.T.)	497,273 oz.	441,297 oz.	450,213 oz.

Source: Annual Reports: Selection Trust

S.T. -- Short Tons.

2.5 Zinc Price Structure and Behaviour

2.5.1 PRICING STRUCTURE

The price structure of zinc in the Free World can be discussed broadly under two headings:
i) the Producer Price;
ii) the London Metal Exchange (LME) Price.

The Producer Price can be sub-divided further into:
a) the U.S. Producer Price;
b) the Canadian Producer Price;
c) the Non-North American (or European) Producers' Price.

At present, most zinc produced is settled on the basis of a Producer Price. Only a small proportion of the total zinc produced in the non-communist world is traded at LME price. It should be emphasized that zinc is sold by the producer at that producer's quoted price. The prices referred to as the U.S. Producer Price, or the European Producer Price, are averaged prices for metal sold in that market over a given period. An historical comparison of the U.S. and European Producer Price for zinc is presented in Figure 2.5.1., along with the London Metal Exchange and scrap prices.

THE U.S. PRODUCER PRICE

The price of zinc in the U.S. market is the producers' quoted price for Prime Western (P.W.) grade slab zinc, delivered. The European equivalent to P.W. grade is Good Ordinary Brand (G.O.B.) zinc. Special High Grade (S.H.G.) zinc is normally sold at a premium over the P.W. grade; currently this premium is ½¢ per pound. High Grade (H.G.) zinc presently carries a premium of ¼¢ per pound over P.W. and Continuous Galvanizing Grade (C.G.G.) zinc is at a premium of up to ½¢ per pound. In times of excess supply in the European market, zinc is sold at a discount below the Producers' Price. It is never sold at prices greater than the quoted price. Adherence to the producers' quoted price is a prevalent feature of the U.S. market.

The settlement price for zinc concentrates is based on payable metal content and the published Producers' Price for Prime Western grade zinc, less smelting charges. The sales contracts for zinc concentrates are very complex. The concentrate supplier is commonly paid for 85% of the zinc metal content, or alternatively a deduction of 8 percentage points may be made to arrive at the payable zinc content. Similar formulae are used to settle the amount to be paid for other values in the concentrate such as silver, gold and cadmium; no payment is made for copper or lead. Minor elements, e.g. selenium, tellurium, indium, etc., are not paid for, nor is the sulphur in the concentrate paid for. In addition a treatment charge is levied against the supplier, and an escalation clause is included in the contract to alter the treatment charge according to fluctuations in the quoted price of zinc while the contract is in force. The bulk of zinc concentrates are treated under contracts which run from one to three years, and may run as long as 8 years. Only minor quantities are sold on a spot price basis.

In January, 1973, the zinc market in the U.S. became disarrayed with the European electrolytic zinc producers raising prices to different levels for the same product. In addition, the Canadian zinc producers introduced a new classification of zinc grade in the U.S. market, called "Contnuous Galvanizing Grade" (C.G.G.). This C.G.G. is a spin-off from the traditional Prime Western grade, primarily used by steel companies for galvanizing. C.G.G. is not subject to the additional 19% ad valorem tariff in the U.S. market, as it is not a zinc alloy.

When the price of zinc was decontrolled by the U.S. Cost of Living Council on December 6, 1973, the U.S. Producers' Price was brought in line with the European Producers' Price in the U.S.

CANADIAN PRODUCER PRICE

The Canadian Producer Price is the quoted price of Prime Western zinc, delivered, and until April, 1972 remained the same as the P.W. grade price in the U.S., but quoted in Canadian currency. Since Canadian domestic consumption is small relative to production, only a small amount of zinc is sold at the Canadian Producer Price. Canadian zinc producers sell their output at different prices in different market sectors. Canadian zinc shipments to the offshore markets are settled on the basis of Non-North American Producers' price and only a very small amount is sold at the LME Price.

The U.S. is the largest single market for Canadian zinc. When the U.S. domestic price was pegged at 18¢/lb. for P.W. by the Cost of Living Council, it created a major disruption in the pricing of Canadian zinc in the U.S. market. Canadian producers quote in U.S. currency in the U.S. market. Noranda and Hudson Bay Mining and Smelting raised their quoted price of P.W. to 19.5¢/lb. while Cominco and Texasgulf were quoting 20¢/lb. in the U.S. market effective January 1, 1973. Between July, 1973 and January, 1976, Texasgulf deviated from the traditional pricing pattern by adding 0.7¢/lb. to the price quoted to U.S. customers to cover the U.S. import tariff, which was usually absorbed by the Canadian producer. At present, the Canadian Producer Price in the U.S. is quoted inclusive of the U.S. tariff. With the withdrawal of the price-freeze on December 6, 1973, the U.S. domestic Producer Price was brought into line with Canadian and other European Producer Prices in the U.S.

NON-NORTH AMERICAN (EUROPEAN) PRODUCER PRICE

Zinc prices in foreign markets are closely tied to the U.S. Producers Price. Prior to 1964, the London Metal Exchange (LME) price was the only basic world price other than the U.S. Prime Western zinc price. At present, the bulk of zinc sales outside North America is settled at the European Producer Price; relatively small volumes are traded at the LME Price.

Zinc producers outside the U.S. established the European Producers' Price in July, 1964 at £123 per tonne (15.625¢ U.S. per lb.) and most zinc outside the North American market was traded on this basis. For instance, Canadian zinc concentrate shipments to Japan are settled at the European Producers' Price. Merchants and dealers continue to trade on the basis of the LME price, while Non-North American zinc producers sell at the European Producers' Price. The price spread between the LME price and the European Producer Price is a reflection of

the difference between near-term and long-term sales contracts, and of the current supply-demand picture.

As a result of the weakening of the British pound sterling in 1975 the Non-North American Producer Price for zinc is no longer quoted in £ per tonne. As of January, 1976 the price is quoted in U.S. dollars per tonne.

THE LONDON METAL EXCHANGE (LME) PRICE

The London Metal Exchange, established in 1877, has evolved into a modern international metal market with three major developments:
1) the introduction of a standardized contract for use between dealers;
2) the change-over from forward dealing for delivery to hedging;
3) the growth of speculation.

The LME is primarily a principals' market. Its members are normally substantial dealers in the physical commodity as well as in future contracts. The Exchange also has facilities for trading in metal commodity futures options granted by the members as principals but these options are not granted by any clearing house.

The major functions of the LME could be identified as:
1) a price making institution for the very much larger international trade in physical metal that lie outside it;
2) a hedging market;
3) a clearing market for excess mine production and for the production of small producers;
4) a buyer's last resort in times of heavy demand and a seller's last resort in times of over production.

The LME has worked well because it functions on a freely fluctuating supply/demand basis for the major non-ferrous metals. Although approximately 60% of all copper mine production in the world is traded internationally on the basis of the LME copper price, it is currently estimated that only about 5% of the total zinc produced in the world moves at the LME price. Moreover, it is important to emphasize that the LME is not a large physical market for zinc. East European zinc sold outside the Communist Block is normally traded on the basis of the LME price.

Prior to 1964, the LME price for zinc was the price at which zinc was sold outside the U.S. With the establishment of the Non-North American (European) Producer Price in 1964, zinc producers sold their zinc at the European Producer Price while merchants and dealers continued to trade on the LME.

Since the prices on the LME are quoted in pound sterling, it follows that any weakening in that currency against others tends to raise the sterling price for zinc. There was a period when, in spite of increased prices in sterling, buyers in hard currency countries did not necessarily pay more for their zinc in terms of their own currency.

A similar consideration holds for Canadian producers selling zinc metal in the U.S. market. Since the price is quoted in U.S. currency, increases in the exchange rate of the Canadian dollar in terms of the U.S. dollar result in decreased Canadian dollar revenues to the Canadian producer from sales in the U.S. market.

2.5.2 PRICE BEHAVIOUR

LONG TERM PRICE BEHAVIOUR

The long-term price trends for zinc metal are shown in Figure 2.5.1, for the period 1946 to 1975. Figure 2.5.2 shows the price trend over the same period for the U.S. producer price, in both current and constant (1971) dollars, to remove the effects of inflation.

The most notable feature of the price behaviour in the 1946-1975 period is the apparent stability of price over the years 1953 to 1971. In these years the price fluctuated (in current dollars) between 10.7¢ and 15.3¢ per pound. The long-term declining trend is apparent in terms of constant dollars, as seen in Figure 2.5.2.

The stability of the price of zinc over this eighteen-year period has been attributed to several factors. The policies of the U.S. Office of Economic Planning and the G.S.A. stockpile program absorbed the production from the excess capacity which had been built up during the World War II and post-war eras. The large quantity of zinc in the stockpile has overhung the market for many years and has acted as a suppressant not only to price increases but to new refining capacity as well during these years. The formation of the International Lead Zinc Study Group in 1960 provided the industry with improved world statistics and forecasting capabilities on supply, demand and international trade. The free-world producers were able to rationalize production according to these forecasts. The supply of concentrates from the large deposits which were discovered and brought into production in this period was a further factor in providing price stability. The constant improvement in productivity and efficiency in the mining and refining sectors of the industry also helped to stabilize prices.

U.S. trade policies strongly influenced the U.S. Producers' Price through the 1950's and 1960's as import quotas and tariffs were imposed to protect the domestic industry against European production capacity. The import quotas on both concentrates and metal were terminated in late 1965. In mid 1975 the tariff on concentrate was temporarily suspended until 1978.

SHORT TERM PRICE BEHAVIOUR

U.S. Producer Price: During 1971 and 1972, the recovery from the mild recession of 1970-71 allowed zinc prices to rise from the 15¢ level to the 20¢ level in the U.S.

The sudden and extreme increase in the price of zinc which occurred in early 1973 was the result of several converging factors. The trends of the U.S. Producers' Price, and the European Producers' Price in the U.S. are shown in Figure 2.5.1. In January, 1973 the zinc market in the U.S. became disarrayed with the foreign electrolytic zinc producers raising prices to different levels for the same product. Initially, in April, 1972, the price was frozen by the U.S. Cost of Living Council (COLC) at 18¢/lb. but it was allowed to rise during 1973 to 20.5¢/lb. (see Figure 2.5.3) while the

foreign producers raised zinc prices to 28¢/lb. in the U.S. When the price of zinc was decontrolled by the COLC on December 6, 1973, the U.S. Producers' Price was brought into line at 27¢/lb., with the foreign producers in the U.S. (see Figure 2.5.3).

Table 2.5.1 provides a comparison of the producer price for different grades of zinc in the U.S. market. During 1974, further increases boosted the price to the 39¢/lb. level.

The New Jersey Zinc Company announced an increase in price of zinc to 41¢/lb. for Prime Western, effective October 10, 1975. This was the first increase in 1975, and New Jersey Zinc attributed this increase to increased labour and energy costs. In view of the depressed demand for zinc in the consumer sectors other major producers did not follow the increase and New Jersey Zinc was forced to roll back its 2¢/lb. increase to 39¢/lb. for Prime Western at the end of October, 1975.

The U.S. zinc producers were facing stiff competition from off-shore producers. In particular, European zinc was being sold to the U.S. importers at less than the list price during the last 5-month period of 1975. This resulted in a further price reduction for zinc in January, 1976. Asarco initiated a 1.5-2¢/lb. price reduction to 37¢/lb. for Prime Western and 37.5¢/lb. for Special High Grade, effective January 5, 1976. Other U.S. and foreign zinc producers followed Asarco's lead. In August, 1976, the U.S. Producer Price for zinc was raised by 3¢/lb. to 40¢/lb. for Prime Western and 40.5¢/lb. for Special High Grade. In October, 1976, the U.S. Producer Price for P.W. zinc was rolled back to 37¢/lb.

Canadian Producer Price: The Canadian price of Prime Western zinc, quoted in Canadian currency, remained the same as the Prime Western grade price in the U.S. until April, 1972. It was then raised to 19¢/lb. while the U.S. domestic price was pegged at 18¢/lb. under the COLC guidelines (see Figure 2.5.3). Further complication with split prices continued when Noranda and Hudson Bay Mining and Smelting raised their quoted price for Prime Western to 19.5¢/lb., while Cominco and Texasgulf increased the price of Prime Western grade to 20¢/lb. in the U.S. market, effective January 1, 1973.

On June 11, 1973, the spread between U.S. and Canadian Producer Prices for Prime Western zinc increased to 2.75¢/lb. Furthermore, Texasgulf raised the price of P.W. to 22.3¢/lb. effective June 13, 1973 and added 0.7¢/lb. to the U.S. customer's price to cover the U.S. import tariff. Quotation of the U.S. price, exclusive of the tariff was a major deviation from the traditional pricing pattern. The subsequent changes in Canadian Producer Price are listed in Table 2.5.1 (see also Figure 2.5.3). The maximum spread between Canadian and U.S. Producer Prices for P.W. zinc was 7.75¢/lb. prior to the withdrawal of the price-freeze on December 6, 1973. Zinc prices in Canada remained at 37¢/lb. for Prime Western between July, 1974 and August, 1976.

Early in August, 1976, Texasgulf Inc., initiated a price increase of 1.5¢/lb. to 38.5¢/lb. in Canada while Noranda and Cominco followed with an increase of 2¢/lb. to 39¢/lb. for Prime Western. Texasgulf Inc., later increased its zinc price by another ½¢/lb., matching other producers in the Canadian zinc market. In October, 1976, the domestic Producer Price for P.W. zinc in Canada was rolled back to 36.25¢ per pound.

Canadian zinc producers sell their outputs at different prices in different market sectors. Texasgulf Inc., the major zinc producer in Ontario quoted the following year-end prices in the U.S. market:

Year	Zinc Price ¢/lb.	% Change from Previous Year
December, 1971	17¢*	+13.33
December, 1972	20¢*	+17.65
December, 1973	31¢**	+55.00
December, 1974	38.3¢**	+23.50
December, 1975	38.3¢**	–
January, 1976	37.0¢*	
August, 1976	40.0¢*	
October, 1976	37.0¢*	

*including the U.S. duty;
**0.7¢/lb. import tariff is added to the quoted price to all U.S. customers.

Non-North American (European) Price Behaviour: An historical comparison of the U.S. and European Producers' Prices for zinc is shown in Figure 2.5.1 along with that for new scrap. In the period 1973 to 1975, a large and sustained price differential existed between the LME and the European Producers' Price (see Figure 2.5.4). The European producers resorted to direct intervention in the LME, to bring this price differential under control, possibly as part of a joint agreement for price maintenance. The direct intervention took the form of purchases and sales from the LME stocks. The European Producers' Price, at which Canadian zinc is sold outside of North America, has changed as outlined in Table 2.5.2. The following summary provides the year-end European Producer Price over the past 5 years.

Year	£ per Tonne	¢/lb. U.S.
December, 1971	150	16.0
December, 1972	173	18.7
December, 1973	300	32.5
December, 1974	360	38.0–33.37*
October, 1975	390*	36.2–35.7*
December, 1975	$795/tonne**	36

*due to the drop in the value of the £ in October, 1975 (£1 = $2.0433).

**Non-EEC zinc producers adopted a dollar basis for their zinc sales instead of sterling due to a drop in the value of the £ from $2.42 in March to $2.02 in December, 1975.

The basis of quotation for the European Producers' Price was changed from sterling to the U.S. dollar at the end of 1975. This was motivated by the drop in value of the Pound from $2.42 in March to $2.02 in December, 1975. Although the European Producers' Price for zinc was raised from £360 to £390 per tonne in October, 1975, this was insufficient to make up for the drop in the value of sterling. The non-EEC zinc producers initiated a change from £390 to $795 per tonne in December, 1975.

The London Metal Exchange (LME) Price: The LME price for zinc has been considerably more erratic than the U.S. Producer Price. This reflects the market's over-reaction to conditons of either excess or shortage of zinc supply to the small traders and dealers. Wide fluctuations in the LME

Price for zinc represent not only the speculative actions, but also the changes in commodity and foreign exchange markets. The LME Price for zinc remained below the U.S. Producer Price from 1952 to 1973, representing balanced market conditions (see Figure 2.5.1). The shortage of zinc metal in 1973 resulted in a large premium in the LME Price over the Producer Price. The spread between the LME and the U.S. Producer Price increased as 1973 progressed and reached a record high, as the price on the LME rose to £935 per tonne (99¢ U.S. per lb.) on December 4, 1973. The Canadian Producer Price in the U.S. was 28¢/lb. and the U.S. Producer Price was frozen at 20.25¢/lb. under U.S. federal price controls. The European Producer Price was quoted at around £300 or 32.5¢ U.S. per lb. in December, 1973. Monthly average zinc prices on the LME are summarized in Table 2.5.3 and shown in relation to the Producer Price outside North America in Figure 2.5.4. The average LME price for the month of December during the past five-year period is summarized as follows:

Period	Average LME Price £/Tonne	% Change from Previous Year
December, 1971	£142.1	+17.8%
December, 1972	159.9	+12.5%
December, 1973	700.2	+337.9%
December, 1974	331.3	–52.7%
December, 1975	338.9	+ 2.3%
July, 1976	434.2	

FIGURE 2·5·1

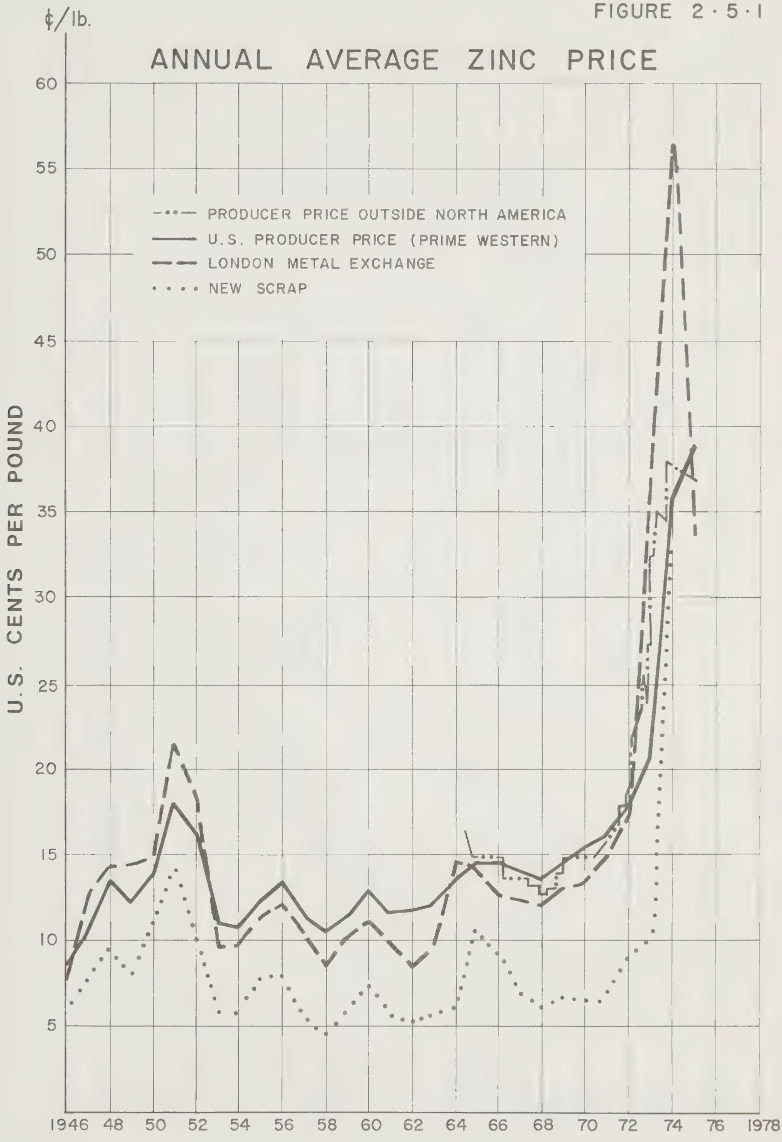

¢/lb.
ANNUAL AVERAGE ZINC PRICE
PRODUCER PRICE OUTSIDE NORTH AMERICA
U.S. PRODUCER PRICE (PRIME WESTERN)
LONDON METAL EXCHANGE
NEW SCRAP
U.S. CENTS PER POUND
60
55
50
45
40
35
30
25
20
15
10
5
1946
48
50
52
54
56
58
60
62
64
66
68
70
72
74
76
1978

Fig. 2.5.2

ANNUAL AVERAGE PRICE OF ZINC
(U.S. PRODUCER PRICE, EAST ST. LOUIS)

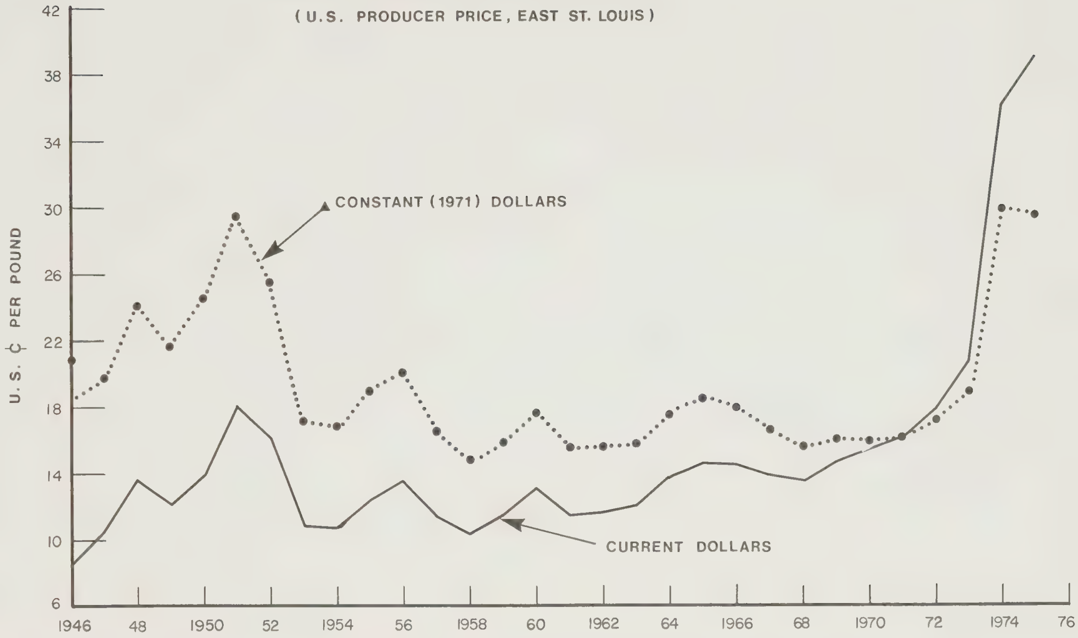


FIGURE 2.5.3

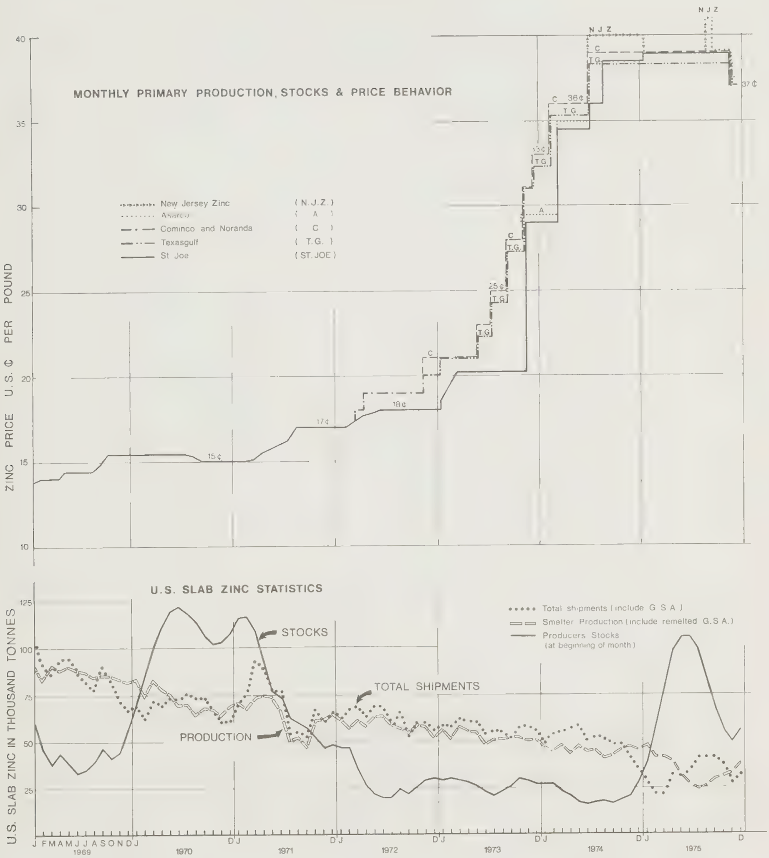

MONTHLY PRIMARY PRODUCTION, STOCKS & PRICE BEHAVIOR
ZINC PRICE U.S. ¢ PER POUND
New Jersey Zinc (N.J.Z.)
Asarco (A)
Cominco and Noranda (C)
Texasgulf (T.G.)
St Joe (ST. JOE)
15¢
17¢
18¢
25¢
36¢
37¢
N J Z
U.S. SLAB ZINC STATISTICS
U.S. SLAB ZINC IN THOUSAND TONNES
Total shipments (include G S A)
Smelter Production (include remelted G.S.A.)
Producers Stocks (at beginning of month)
STOCKS
TOTAL SHIPMENTS
PRODUCTION
1969
1970
1971
1972
1973
1974
1975

FIGURE 2 · 5 · 4

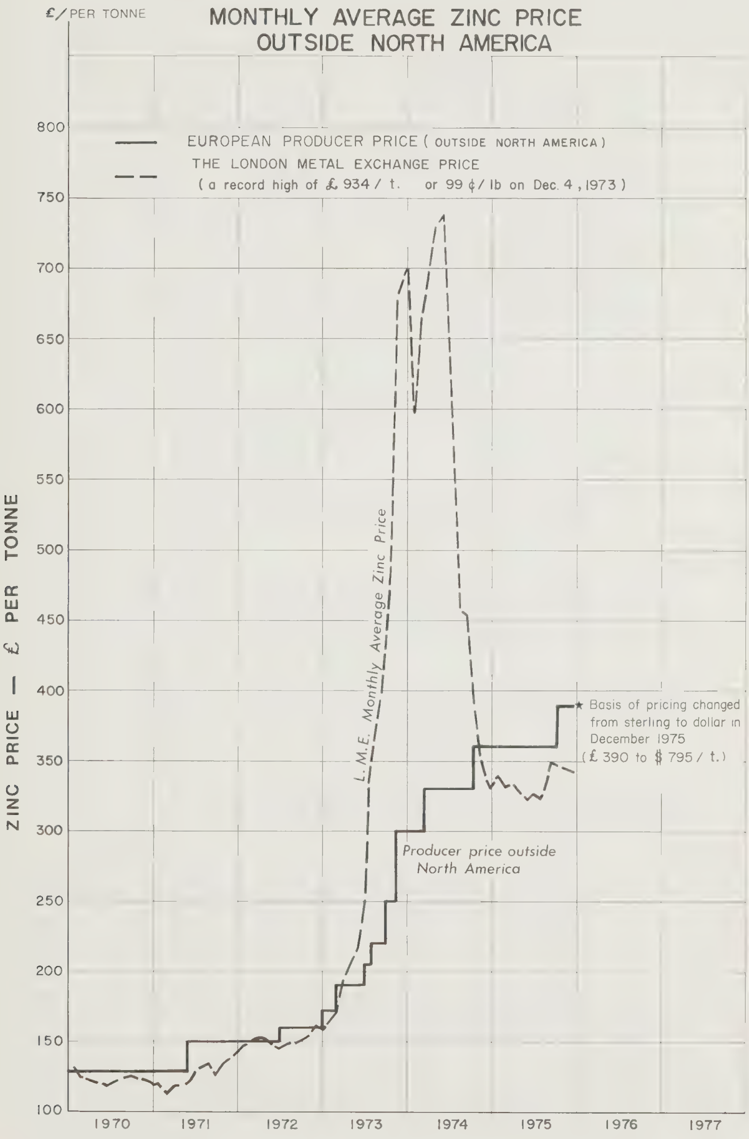

£/PER TONNE
MONTHLY AVERAGE ZINC PRICE
OUTSIDE NORTH AMERICA
EUROPEAN PRODUCER PRICE (OUTSIDE NORTH AMERICA)
THE LONDON METAL EXCHANGE PRICE
(a record high of £ 934 / t. or 99 ¢ / lb on Dec. 4 , 1973)
L.M.E. Monthly Average Zinc Price
Producer price outside
North America
★ Basis of pricing changed
from sterling to dollar in
December 1975
(£ 390 to $ 795 / t.)
ZINC PRICE — £ PER TONNE
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
1970
1971
1972
1973
1974
1975
1976
1977

TABLE 2.5.1

COMPARATIVE PRODUCER PRICES FOR DIFFERENT GRADES OF ZINC

		COMINCO	NORANDA	TEXAS-GULF	HUDSON BAY M & S	AMAX	ASARCO	ST. JOE	NEW JERSEY ZINC	NATIONAL ZINC	BUNKER HILL
						U.S. CENTS PER POUND					
Dec. 19, 1972	P.W.	20.00	19.50	20.00	19.50	18.00	18.00	18.00	18.00	18.00	18.00
	C.G.G.	20.25	19.50	20.25	19.50	18.25	18.25	18.25	18.25	18.25	18 25
	H.G.	20.35	20.35	20.35	20.35	18.85	18.85	18.85	18.85	18.85	18.85
	S.H.G.	20.50	20.50	20.50	20.50	19.00	19.00	19.00	19.00	19.00	19.00
Jan. 1, 1973	P.W.	20.00	19.50	20.00	19.50	18.00	18.00	18.52	18.50		
	C.G.G.	20.25	19.75	20.25	19.75	18.25	18.25	18.78	18.25		
	H.G.	20.35	20.35	20.35	20.35	18.85	18.85	19.40	19.35		
	S.H.G.	20.50	20.50	20.50	20.50	19.00	19.00	19.55	19.50		
Jan. 25, 1973	P.W.	21.00	21.00	20.00	21.00	19.25	19.00	19.25	19.25	19.50	M.W. Avg.
March 1973	C.G.G.	21.50	21.50	20.25	21.50	20.00	19.25	20.00	19.95	20.00	M.W. Avg.
	H.G.	21.00	21.00	20.35	21.00	20.35	N.A.	20.35	20.10	N.A.	M.W. Avg.
	S.H.G.	21.50	21.50	20.50	21.50	20.50	20.00	20.50	20.25	N.A.	M.W. Avg.
April 1, 1973	P.W.	21.00	21.00	20.00	21.00	20.25	20.25	20.25	20.25	20.50	20 50
	C.G.G.	21.50	21.50	20.25	21.50	21.00	20.50	21.00	20.50	21.00	21.00
	H.G.	21.00	21.00	20.35	21.00	21.35	N.A.	21.35	N.A.	N.A.	21.35
	S.H.G.	21.50	21.50	20.50	21.50	21.50	21.25	21.50	21.25	N A.	21.50
June 11, 1973	P.W.	23.00	23.00	22.30*	23.00*	Prices were frozen by the Cost of Living Council					
	C.G.G.	23.50	23.50	22.80*	23.50*						
	H.G.	23.00	23.00	22.30*	23.00*						
	S.H.G.	23.50	23.50	22.80*	23.50*						

TABLE 2.5.1 cont'd

		COMINCO	NORANDA	TEXAS-GULF	HUDSON BAY M & S	AMAX	ASARCO	ST. JOE	NEW JERSEY ZINC	NATIONAL ZINC	BUNKER HILL
July 26, 1973	P.W.	25.00	25.00	24.30*	25.00*	Prices were frozen by the Cost of Living Council					
	C.G.G.	25.50	25.50	24.80*	25.50*						
	H.G.	25.00	25.00	24.30*	25.00*						
	S.H.G.	25.50	25.50	24.80*	25.50*						
Sept. 24, 1973		28.00	28.00	27.30*	28.00*						
(Oct. 1 for T.G.)		28.50	28.50	27.80*	28.50*						
		28.00	28.00	27.30*	28.00*						
		28.50	28.50	27.80*	28.50*						
Dec. 10 & 11, 1973	P.W.	31.00	31.00*	31.00*	31.00*	N.A.	29.00	28.00	32.00	29.50	32 00
(Dec. 21 for	C.G.G.	31.50	31.50	31.50*	31.50*	N.A.	30.50	29.00	N.A.	N.A.	34.00
Cominco)	H.G.	31.00	31.00	31.00*	31.00*	N.A.	N.A.	29.30	32.85	N.A.	N.A.
See Jan. 7, 1974	S.H.G.	31.50	31.50	31.50*	31.50*	28.50	30.50	N.A.	33.00	N.A.	33.50
M.W.		Del.	Del.			f.o.b. sm.	Del.	f.o.b. sm.	Del.	f.o.b. sm.	Del.
Jan.–Feb. 1974	P.W.	33.00	33.00	32.30*	33.00*				32.00		
	C.G.G.	33.50	33.50	32.80*	33.50*				N.A.		
	H.G.	33.00	33.00	32.55*	33.00				33.25		
	S.H.G.	33.50	33.50	32.80*	33.50*				33.50		
effective		Jan. 23	Feb. 1	Mar. 1	Feb. 1				Feb. 11		
March– April 1, 1974	P.W.	36.00	36.00	35.30*	36.00*	N.A.	35.00	34.50	35.00	35.00	
	C.G.G.	36.50	36.50	35.80*	36.50*	37.50	36.50	36.00	N.A.	N.A.	
	H.G.	36.00	36.00	36.00*	36.00*	N.A.	N.A.	36.50	N.A.	N.A.	
	S.H.G.	36.50	36.50	35.30*	36.50*	36.50	36.50	N.A.	36.50	N.A.	
effective			Apr. 1		Apr. 2	Mar. 29	Mar. 28	Mar. 25	Mar. 14	Mar. 26	
June–July 1974	P.W.	39.00	39.00	38.30*	39,00*	N.A.		36.00	40.00	36.00+2	
	C.G.G.	39.50	39.50	38.80*	39.50*	40.00		37.50	N.A.	N.A.	
	H.G.	39.00	39.00	38.30*	39.00*	N.A.		38.00	N.A.	N.A.	
	S.H.G.	39.50	39.50	38.80*	39.50*	39.00		N.A.	41.50	N.A.	
effective		Aug. 9	July 29	Jul. 16				Jul. 16	Jul. 10	June 3	

TABLE 2.5.1 cont'd

		COMINCO	NORANDA	TEXAS-GULF	HUDSON BAY M & S	AMAX	ASARCO	ST. JOE	NEW JERSEY ZINC	NATIONAL ZINC	BUNKER HILL
Sept. 1974	P.W.							38.50	39.0	39.50	
	C.G.G.							40.00	39.25	N.A.	
	H.G.							40.50	N.A.	N.A.	
	S.H.G.							N.A.	39.5	N.A	
effective								Sept. 4		Sept. 10	
October 10, 1975	P.W.								41.0		
	C.G.G.								41.25		
	H.G.								N.A.		
	S.H.G.								41.5–		
									Oct. 10 1975		
effective											
October 31, 1975	P.W.								39.0		
	C.G.G.								39.25		
	H.G.								N.A.		
	S.H.G.								39.5		
									Oct. 31 1975		
effective											
Jan. 5, 1976	P.W.	37.0	37.0	37.0**			37.0	37.0	37.0		
	C.G.G.	37.5	37.5	37.25			37.25	37.25	37.25		
	H.G.	37.0	37.0	37.0			N.A.	37.5	N.A.		
	S.H.G.	37.5	37.5	37.5			37.5	N.A.	37.5		
effective				Jan. 8 1976			Jan. 5 1976		Jan 5 1976		

* – 0.7¢/lb. import tariff in the U.S. is added to the quoted prices.
** – including the U.S. duty
N.A. – Not applicable
P.W. – Prime Western Grade
C.G.G. – Continuous Galvanizing Grade
H.G. – High Grade
S.H.G. – Special High Grade

TABLE 2.5.2

EUROPEAN PRODUCERS' PRICE OUTSIDE NORTH AMERICA

	£/TONNE	EQUIVALENT ¢/lb. (1)
July '64 – Sept. '64	£123.027	16.8
Sept. 4, '64 – March 23, '66	108.263	14.7
March 23, '66 – June '67	100.39	13.7
June '67 – Nov. '67	96.45	13.2
Nov. '67 – May '69	112.57	12.2 to 12.6 *
May '69 – Oct. '69	119.09	12.96
Oct. '69 – Dec. '69	127.95	13.93
Jan. '70 – June '71	127.95	13.93 to 14.8
June '71 – July '72	150	15 to 17.7
July '72 – Nov. '72	160	17.7 *
Dec. '72 – Feb. 26, '73	173	18.5 to 19.3
Feb. 26, '73 – June 5, '73	190	21.5 to
June 6, '73 – July 10, '73	205	21.5 to 23.9
July 11, '73 – Sept. 29, '73	220	25.4 to 24.0
Sept. 20, '73 – Nov. 18, '73	250	27.3
Nov. 19, '73 – March 12, '74	300	32.5
March 12, '74 – Sept. 12, '74	330	35.1 to 34.5
Sept. 13, '74 – Oct. 8, '75	360	37.8 to 33.4**
Oct. 9, '75 –	390	36.2 to 35.7
December '75	$795/t	36¢/lb.

Source: Zinc, E.M.R., Ottawa – Annual Reviews

(1) Canadian funds from 1964 to 1967; and U.S. funds from 1967.

* – This adjustment was made to offset the loss of exchange value.

** – This represents weak £ on foreign exchange market in October 1975 (£1 = $2.0433)

TABLE 2.5.3

**THE LONDON METAL EXCHANGE
AVERAGE MONTHLY ZINC PRICE
AND MONTH-END ZINC STOCKS**

YEAR			JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1973	(i)	Average Price £/Tonne	164.40	173.69	191.90	206.25	216.93	254.56	331.39	369.24	403.23	477.87	676.50	697.03
	(ii)	Month-End Stocks Tonnes	25,050	22,850	21,250	20,275	17,825	18,200	16,600	15,125	11,625	8,675	5,125	8,125
1974	(i)	Average Price £/Tonne	597.9	666.7	696.5	728.8	738.4	589.8	458.9	454.1	393.5	353.6	341.5	331.3
	(ii)	Month-End Stocks Tonnes	9,375	4,825	8,650	8,650	5,900	17,300	14,000	18,450	19,925	17.650	17,850	13,500
1975	(i)	Average Price £/Tonne	338.2	331.4	332.1	330.1	321.9	329.2	323.6	348.4	347.2	343.1	344.1	339.1
	(ii)	Month-End Stocks Tonnes	14,250	12,000	13,150	13,050	16,100	8,550	23,075	29.575	43,375	61,825	69,775	73,275
1976	(i)	Average Price £/Tonne	340.9	340.4	374.0	427.7	427.6	424.4	434.2	415.0	412.2			
	(ii)	Month-End Stocks Tonnes	52,450	47,175	46,100	50,050	65,475	78,950	87,575	96.700	105,000			

TABLE 2.5.4

ANNUAL AVERAGE PRICE OF ZINC

(U.S. Producer Price)

Year	Price of Zinc (¢ U.S./lb.)	Deflated Price ≠ (1971 Constant Dollars)
1946	8.73	18.50
1947	10.50	19.89
1948	13.58	24.12
1949	12.15	21.70
1950	13.88	24.48
1951	17.99	29.69
1952	16.21	26.19
1953	10.86	17.38
1954	10.69	16.86
1955	12.29	19.11
1956	13.49	20.29
1957	11.39	16.51
1958	10.31	14.58
1959	11.45	15.93
1960	12.95	17.72
1961	11.54	15.60
1962	11.63	15.55
1963	11.99	15.82
1964	13.57	17.62
1965	14.50	18.50
1966	14.50	17.99
1967	13.84	16.64
1968	13.50	15.61
1969	14.60	16.10
1970	15.32	16.01
1971	16.13*	16.13
1972	17.75*	17.17
1973	20.66*	18.92
1974	36.0 *	29.90
1975	38.9 *	29.56

≠ Sources: 1967 supplement to Economic Indicators, Historical and Descriptive Background; Economic Indicators, Dec. 1975

* Deliver Basis

2.6 Slab Zinc Stocks and Price Behaviour

The level of slab zinc stocks plays a major role in determining the short-run price of zinc, and also influences the level of production. A regression analysis of U.S. zinc prices versus total U.S. zinc stocks shows a strong correlation between the two (see Figure 2.6.1). The data used was the monthly average U.S. Producers' Price and the total month-end stocks of the producers, consumers and the G.S.A. stocks, over the period January, 1972 to January, 1976. The data is given in Table 2.6.3 and shown in Figure 2.6.2. The regression analysis yielded a highly significant co-efficient of correlation of 0.96.

A similar regression analysis of the LME warehouse zinc stocks against the LME spot price indicated a correlation co-efficient of 0.85. Each 1000 tonnes decline in the LME stocks is associated with an increase in the spot price of about £30 per tonne during the 1973-1974 period (see Figure 2.6.4).

The sensitivity of price to stocks is a reflection of the relative inelasticity of supply to the demand for zinc in the short-term. The fluctuations in zinc stocks between 1969 and 1972 illustrate the relationship between stocks, production level and price (see Figure 2.6.5). The zinc stocks discussed here are 85% of total Free World stocks for which data are available, and the price is the U.S. Producers' Price. In January, 1969, zinc stocks remained well below the normally acceptable level of one month's supply of 260 000 tonnes. Between January and December the stocks increased by 41%, reaching 273 000 tonnes, to exceed the "magic level" of one month's production, and the price increased from 13.8¢ to 15.5¢/lb. In 1970, further accumulation of stocks, to a level of 390 000 tonnes, resulted in production cut-backs to 227 000 tonnes per month, and a price decrease to 15¢/lb. In January of 1971, stocks reached a record high of 404 000 tonnes, but as the economic recovery gained strength during the year, stocks fell to 328 000 tonnes, production reached full operating capacity, and the price rose from 15¢/lb. to 17¢/lb. by the end of the year. A surge in zinc demand in the first half of 1972, coupled with dwindling U.S. production capacity, resulted in a further drop in stocks, to 218 000 tonnes by June, 1972. This three-year low level, well below one month's supply, created an upward pressure on zinc price, which reached 18¢–20¢/lb.

2.6.1 U.S. STOCKS

Slab zinc stocks in the U.S. market are discussed under three categories: producers' stocks, consumers' stocks and the government G.S.A. stockpile.

U.S. PRODUCERS' STOCK

Producers' slab zinc stocks at the smelters in the U.S. are tabulated in Table 2.6.3 (see Figure 2.5.3). Between February and June, 1972, the U.S. producers' stocks declined from 116 000 tonnes to 19 300 tonnes, their lowest level in 15 years. Stocks climbed slowly to 29 600 tonnes by February, 1973 as smaller zinc producers refrained from selling at the U.S. price of 18¢/lb. During 1973 producers' stocks again declined until July, and then increased until October. In the meantime the European Producers' Price in the U.S. market reached 28¢/lb., while the U.S. Cost of Living Council (COLC) froze the domestic Producers' Price at 20.5¢/lb. The freeze was lifted on December 6, 1973. The U.S. Producers' stocks continued to decline, reaching the record low of 16 000 tonnes in early June, 1974. The Producers' Price reached its peak of 40¢ per pound when New Jersey Zinc announced its increase on July 10, 1974. Producers' stocks began to increase as the economic recession of 1974-75 took hold, climbing to 105 200 tonnes by June, 1975. Stocks fell to 49 000 tonnes at the end of October, 1975 as the production cut-backs began to take effect, and rose to 67 000 tonnes by the end of January, 1976.

THE U.S. CONSUMER STOCKS

Slab zinc stocks held by U.S. consumers during the past 5-year period are summarized in Table 2.6.1. The year-end total of consumers' slab zinc inventories declined 11% during 1970 and increased 10% and 41% in 1971 and 1972 respectively. Year-end consumers' zinc stocks fell by 24% from 126 000 tonnes in 1972 to 95 000 tonnes at the end of 1973. During 1974 the U.S. consumers' slab zinc stocks increased by 101% to 191 000 tonnes at the year-end, but stocks have declined during 1975, reaching 89 000 tonnes at the end of December, 1975.

THE U.S. GOVERNMENT STOCKPILE

In the U.S.A., the concept of stockpiling essential raw materials dates back to the early 1920's. A formalized stockpile plan was implemented with the passage of the Strategic and Critical Material Stockpiling Act, 1947. Materials gathered under this Act are termed "National Stockpiles" and require congressional authorization for their purchase or sale.

Having authorized and established a national security stockpile of zinc in the U.S., acquisition of zinc commenced in 1946 and continued during the Korean War. A supplemental stockpile was further established in 1956 providing for acceptance of foreign produced zinc in exchange for certain agricultural commodities through barter arrangements. On termination of this programme in 1959, inventories of zinc in the U.S. General Service Administration (G.S.A.) stockpile reached a record high of 1 436 000 tonnes. Table 2.6.2 summarizes the status of the stockpile from 1945 to 1975. Figure 2.6.3 shows the changes in stockpile objective, the authorized tonnage of zinc for disposal from the stockpile and the total zinc in the G.S.A. stockpile from 1968 to 1975.

The Office of Emergency Planning Mobilization Study in 1963 initiated a program to reduce the total zinc stockpile goal to zero. In 1965, the first zinc disposals were authorized and in 1969 the stockpile objective was reduced to 453 000 tonnes. In 1972, Congress authorized the release of a total of 467 000 tonnes, 399 000 tonnes for sale to the consuming industry through the U.S. domestic producers, and 68 000 tonnes through sales on an off-the-shelf basis. In April, 1973, the zinc stockpile objective was again reduced, to a level of 184 000 tonnes, authorizing the G.S.A. to release a further 324 000 tonnes of zinc from the stockpile.

Prior to 1972, the U.S. G.S.A. zinc stocks contained over 1 million tonnes. A record demand for zinc coupled with reduced domestic production capacity, increased the sales from the stockpile in 1973 to 282 000 tonnes from the 171 000 tonnes in 1972. The G.S.A. sales of stockpiled

zinc during 1974 reached an estimated 241 000 tonnes, leaving approximately 154 000 tonnes for release under the then-current authorizations. Since December 1974, no deliveries against contracts between the G.S.A. and U.S. zinc producers have been made, because of ample stocks held by the producers. On June 28, 1976 the United States Federal Preparedness Agency raised the official objective of zinc to 340 040 tonnes, equal to the entire quantity in the strategic stockpile at that time.

On October 1, 1976, the Federal Preparedness Agency (FPA) announced new stockpile objectives for 93 critical and strategic materials. The objective for zinc was raised from 340 040 tonnes to 1.19 million tonnes. Funds to buy materials for the stockpile must be appropriated by Congress and FPA did not foresee acquisition beginning before October, 1977.

2.6.2 THE LONDON METAL EXCHANGE STOCKS

Declining zinc stocks and increasing prices, similar to the behaviour exhibited in the U.S. zinc market, have been observed on the London Metal Exchange. The L.M.E. zinc stocks declined from 34 800 tonnes in December, 1972 to 5100 tonnes in November, 1973 while the average monthly L.M.E. spot price for zinc increased from £159.9 per tonne (16.99¢/lb.) in December, 1972 to £697 per tonne (73¢/lb.) in December, 1973 (see Figure 2.6.4). A record high of £935 per tonne (99¢/lb.) was established for L.M.E. spot zinc on December 4, 1973, while the L.M.E. zinc stock reached its lowest level at 3250 tonnes on February 9, 1974. The L.M.E. zinc stocks gradually increased to 19 000 tonnes in September and then dropped to 13 500 tonnes at the end of December, 1974. The monthly average price dropped to £331.30 per tonne (34.99¢/lb.) during December, 1974. The monthly average price for zinc on the L.M.E. varied from a low of £321.9 to a high of £348.4 per tonne during 1975 (see Table 2.5.3) while the total L.M.E. zinc stocks climbed to a high of 73 300 tonnes at the end of December, 1975.

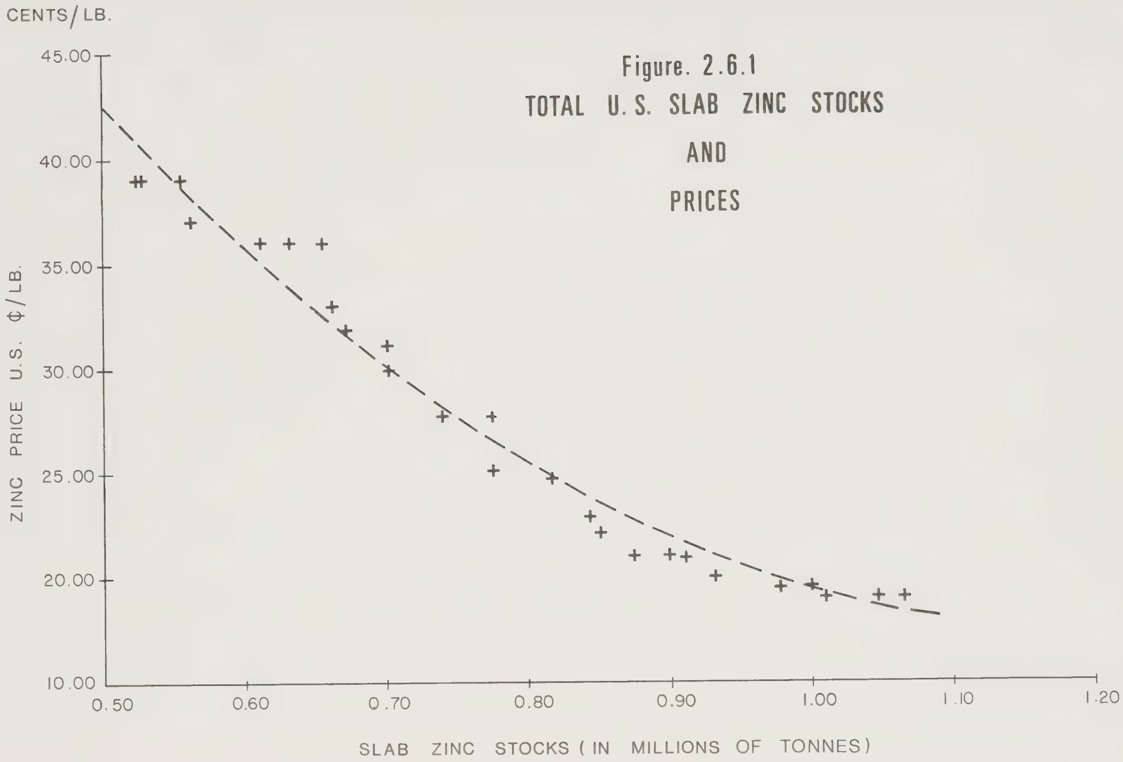


Figure. 2.6.1
TOTAL U.S. SLAB ZINC STOCKS
AND
PRICES

FIGURE 2.6.2

THE U.S. ZINC STOCKS AND PRICE BEHAVIOR

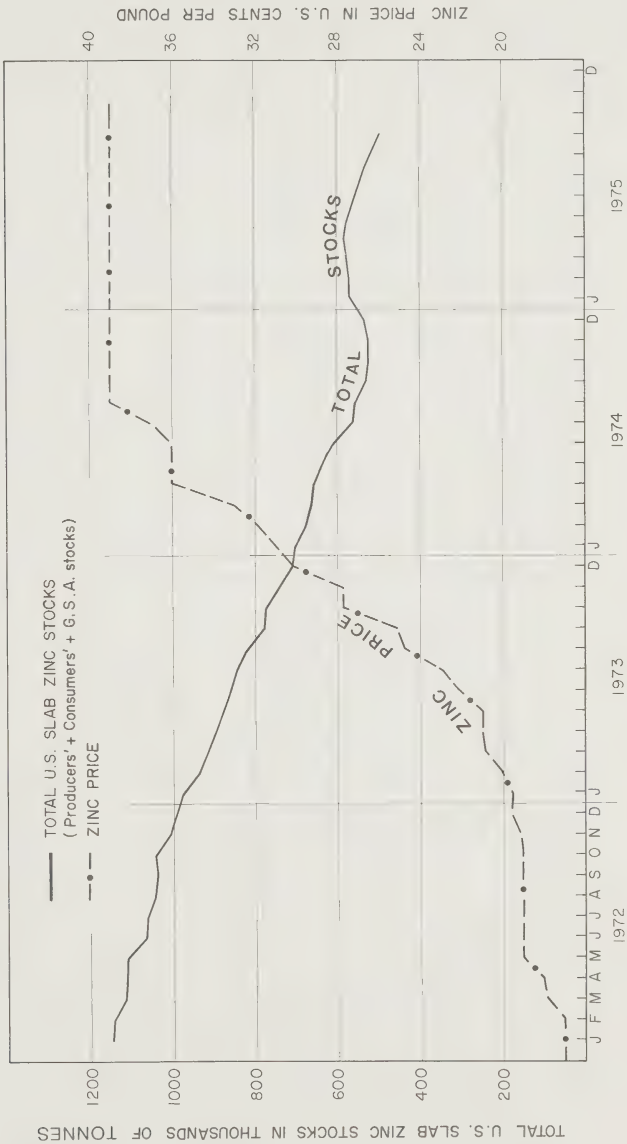


FIGURE 2 · 6 · 3

THE U.S. GOVERNMENT - GENERAL SERVICE ADMINISTRATION ZINC STOCKPILE

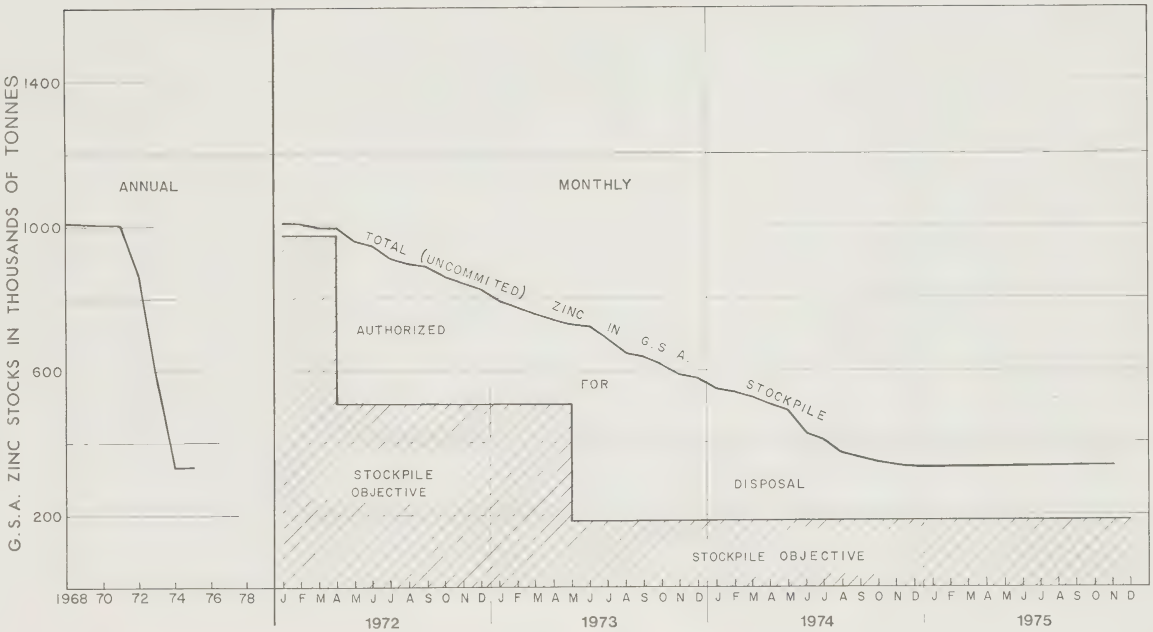


FIGURE- 2·6·4

THE LONDON METAL EXCHANGE
ZINC STOCKS AND PRICE BEHAVIOR

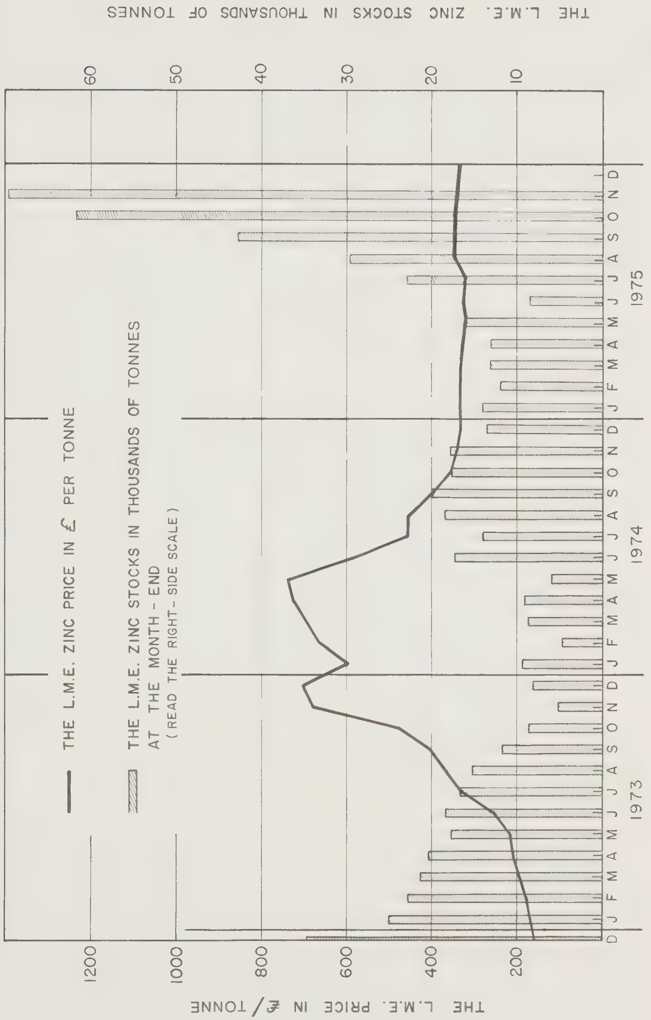


Figure: 2.6.5

MONTHLY PRODUCTION AND STOCKS OF REFINED ZINC

(85 % of the Free World)

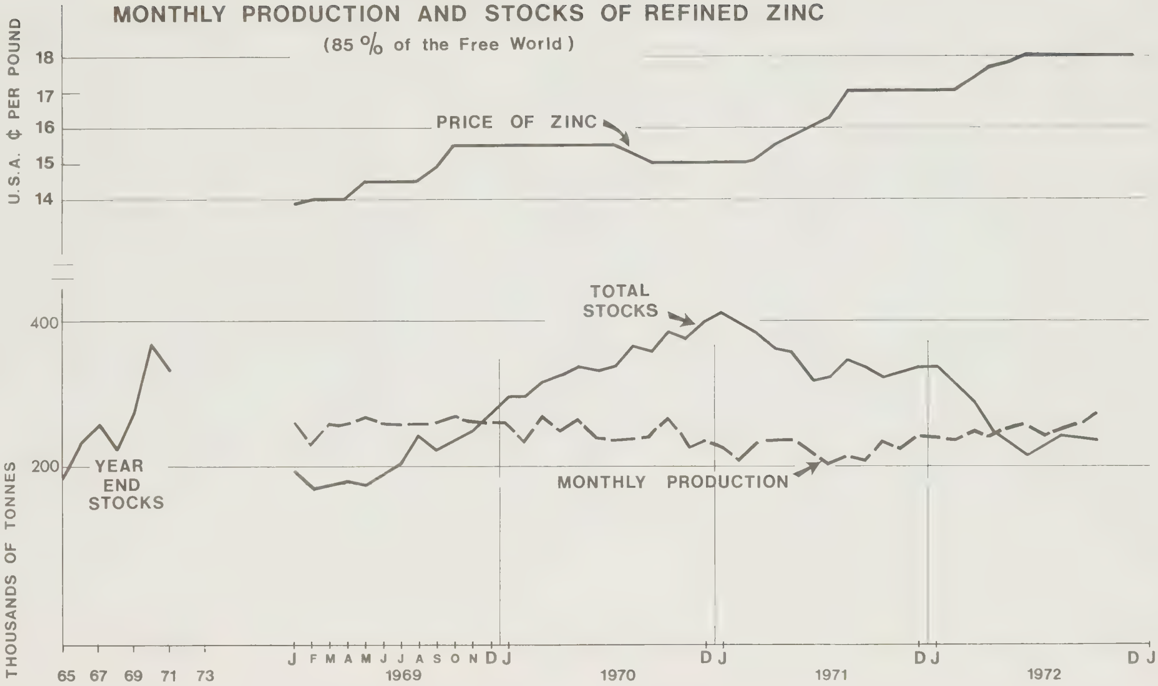


TABLE 2.6.1

THE U.S. CONSUMER SLAB ZINC STOCKS

YEAR-END	CONSUMER SLAB ZINC STOCKS TONNES	% CHANGE: INCREASE OR (DECREASE) FROM PREVIOUS YEAR
1970	81,241	(11%)
1971	89,228	10%
1972	125,935	41%
1973	95,169	(24%)
1974	191,200	100.9%
1975	89,000	(53.5%)

Source: U.S. Bureau of Mines

TABLE 2.6.2

UNITED STATES GOVERNMENT
GENERAL SERVICES ADMINISTRATION
ZINC STOCKS

YEAR	NET PURCHASES OR RELEASES (–)	YEAR-END STOCKS
	Tonnes	
1945	0	0
1946	62,798	62,798
1947	21, 916	84,714
1948	360,346	445,060
1949	94,403	539,464
1950	44,896	584,359
1951	4,551	588,911
1952	11,386	600,297
1953	35,023	635,320
1954	112,621	747,940
1955	128,900	876,840
1956	164,345	1,041,185
1957	285,140	1,326,325
1958	78,210	1,404,535
1959	32.050	1,436,585
1960	–4,395	1,432,190
1961	814	1,433,004
1962	264	1,433,268
1963	938	1,434,206
1964	–68,680	1,365,525
1965	–174,511	1,191,014
1966	–91,172	1,099,842
1967	–12,924	1,086,918
1968	–34,034	1,052,884
1969	–16,712	1,036,167
1970	–630	1,035,537
1971	–3,223	1,032,314
1972	–170,872	861,443
1973	–282,273	579,170
1974	–241,062	338,108
1975P		349,914

Source: U.S. Bureau of Mines, Lead-Zinc Study Group
P – Preliminary

TABLE 2.6.3

THE U.S. SLAB ZINC STOCKS AND PRICES

(Tonnes)

YEAR	AT THE BEGINNING OF THE MONTH	PRODUCER STOCKS (1)	CONSUMER STOCKS (2)	GOVERNMENT STOCKPILE (3)	TOTAL PRIVATE-SECTOR (4) = (1) + (2)	TOTAL STOCKS (5) = (1) + (2) + (3)	NET INCREASE OR (DECREASE) OF TOTAL STOCKS	CANADIAN ZINC IN U.S. PRICE ¢/LB.	CHANGE IN PRICE ¢/LB INCREASE OR (DECREASE)
1972	Jan.	45,894	89,228		135,122	1,149,277		17.0	0
	Feb.	45,806	86,100	1,014,155	131,906	1,146,061	(3,216)	17.0	0
	March	34,286	83,497	1,013,653	117,783	1,131,436	(14,625)	17.9	0.9
	April	26,698	88,423	995,501	115,121	1,110,622	(20,814)	18.0	0.1
	May	21,247	84,576	995,485	105,823	1,101,308	(9,314)	19.0	1.0
	June	19,252	87,947	958,239	107,199	1,065,438	(35,870)	19.0	0
	July	19,337	101,094	943,665	120,431	1,064,096	(1,342)	19.0	0
	Aug.	24,204	113,378	908,708	137,582	1,046,290	(17,806)	19.0	0
	Sept.	21,283	125,542	891,443	146,825	1,038,268	(8,022)	19.0	0
	Oct.	25,420	130,907	884,894	156,327	1,041,221	2,953	19.0	0
	Nov.	28,344	127,404	854,197	155,748	1,009,945	(31,276)	19.1	0.1
	Dec.	29,306	130,533	840,017	159,839	999,856	(10,089)	19.5	0.4
1973	Jan.	28,826	125,935	822,514	154,761	977,275	(22,581)	19.5	0
	Feb.	29,622	112,432	790,073	142,054	932,127	(45,148)	20.0	0.5
	March	28,404	109,900	773,404	138,304	911,708	(20,419)	20.9	0.9
	April	27,577	115,586	756,735	143,163	899,898	(11,810)	21.0	0.1
	May	25,466	109,661	739,858	135,127	874,985	(24,913)	21.0	0
	June	22,333	103,442	725,062	125,775	850,837	(24,148)	22.1	1.1
	July	20,111	100,650	723,130	120,761	843,891	(6,946)	22.9	0.9
	Aug.	22,761	105,522	688,899	128,283	817,182	(26,709)	24.7	1.8
	Sept.	24,825	104,459	646,788	129,284	776,072	(41,110)	25.1	0.4
	Oct.	29,317	106,826	639,169	136,143	775,312	(760)	27.7	2.6
	Nov.	28,703	96,787	614,382	125,490	739,872	(35,440)	27.7	0
	Dec.	26,979	92,350	582,699	119,329	702,028	(37,844)	29.9	2.2
1974	Jan.	26,575	95,169	579,170	121,744	700,914	(1,114)	31.0	1.1
	Feb.	27,063	101,174	543,117	128,237	671,354	(29,560)	31.8	0.8
	March	22,742	99,728	539,316	122,470	661,786	(9,568)	33.0	1.2
	April	20,737	111,482	523,600	132,219	655,819	(5,967)	36.0	3.0
	May	17,016	111,679	503,894	128,695	632,589	(23,230)	36.0	0
	June	16,004	106,821	489,035	122,825	611,860	(20,729)	36.0	0
	July	17,297	121,626	423,123	138,933	562,056	(49,804)	37.0	1.0
	Aug.	17,798	134,970	402,214	152,768	554,982	(7,074)	39.0	2.0
	Sept.	16,464	144,805	366,399	161,269	527,668	(27,314)	39.0	0
	Oct.	18,387	148,950	356,919	167,337	524,256	(3,412)	39.0	0
	Nov.	18,387	160,100	346,461	178,487	524,948	692	39.0	0
	Dec.	20,017	166,300	338,108	194,317	523,425	7,477	39.0	0
1975	Jan.	38,916	191,200	337,907	230,116	568,023	31,598	39.0	0
	Feb.	58,434	174,500	337,907	232,934	570,841	2,818	39.0	0
	March	77,993	162,200	338,745	240,193	578,938	8,097	39.0	0
	April	98,021	146,400	338,905	244,421	583,326	4,388	39.0	0
	May	104,928	133,600	338,905	238,528	577,433	(5,893)	39.0	0
	June	105,198	115,000	339,481	220,198	559,679	(17,754)	39.0	0
	July	98,506	103,500	339,794	202,006	541,800	(17,879)	39.0	0
	Aug	82,109	93,700	339,840	175,809	515,649	(26,151)	39.0	0
	Sept.	66,706	86,400	339,840	153,106	492,946	(22,703)	39.0	0
	Oct.	55,298	82,200					39.0	0
	Nov.	49,011	83,800					39.0	0
	Dec.	55,087						39.0	0
1976	Jan.							37.0	(2.0)
1976	Aug							40.0	3.0
1976	Oct.							37.0	(3.0)

2.7 Trade Barriers

2.7.1 TARIFFS

A profile of post-Kennedy Round tariffs of zinc in the major market areas is presented in Table 2.7.1. Tariffs represent an important constraint to increased zinc metal production in Canada.

E.E.C.: The E.E.C. tariffs in the zinc sector are a classic example of escalation from free entry for concentrates, to 3.5% ad valorem for zinc metal, and to a range of 6.0%–10.0% for a variety of products based on zinc metal. At present (1976) several E.E.C. member countries impose tariff rates which differ from the 3.5% rate of the E.E.C.; the U.K. imposes a 2.85% ad valorem rate, and Ireland and Denmark also have differing rates. Effective July 1, 1977, the E.E.C. tariff rate for refined zinc will become uniform at 3.5% ad valorem for all member countries. The tariff on zinc metal becomes applicable only after a duty-free quota has been reached. In 1972 the duty-free quota for refined zinc entering the E.E.C. was 22 980 tonnes, amounting to 17% of total E.E.C. imports of refined zinc from non-member countries. The duty-free quota has been lowered in each successive year over the past 4 years, to 20 700 tonnes in 1974, 15 000 tonnes in 1975 and to 9000 tonnes in 1976. The proposed quota for the first half of 1977 is 5000 tonnes, and effective July 1, 1977 the quota will be reduced to zero.

Japan: Japanese tariffs also escalate by the degree of processing. Concentrates enter duty-free. The bound GATT rate for zinc metal is 8 yen/kg. The ad valorem equivalent of this rate, on the basis of 1970 import values, was 7.1 percent. However, under a temporary rate, the specific duty and therefore its ad valorem equivalent is reduced on a sliding scale as zinc prices increase. In 1973, the sliding scale in effect was as follows:

c.i.f. value in ¢/lb.	duty, in ad valorem equivalent
up to 17.6	falling from very high rates to 7.5% at 17.6¢/lb.
from 17.6 to 19.0	falling from 7.5% to free
over 19.0	free

In the late 1960's the Japanese producers' price, roughly equivalent to the landed c.i.f. price of foreign metal, was below the level at which duties on imported metal became applicable. However, since 1970 in a tightening international market, the Japanese producers' price has been above that level, indicating that duties have not been applicable to foreign metal. Therefore, at least in recent months, Japanese tariffs have not in themselves impeded processing to the metal stage in Canada.

The U.S.A.: Of the major markets for Canadian zinc, the U.S.A. was the only one that (until August 9, 1975) imposed a tariff on concentrates as well as on metal. The tariffs were 0.67¢/lb* on zinc contained in concentrates and 0.7¢/lb. on zinc metal. It can be interpreted that the current structure of tariffs in the U.S.A. does not influence the degree of upgrading in Canada insofar as concentrates and metal are concerned. However, the U.S.A. is at a crossroad in its policy towards the domestic zinc industry. On the one hand, there has been some pressure for moving towards freer trade, as evidenced by the introduction in Congress of Bill HR 9362 in July, 1973, calling for a two year suspension of tariffs on zinc metal. On the other hand, Bill HR 6437, submitted in April, 1973, seeking a tariff-quota on refined zinc, and Bill HR 6191 of March, 1973 and S 2184 of July, 1973, calling for a two year suspension of the tariffs on zinc concentrates, together indicate that the U.S. producers are attempting to encourage smelting of imported concentrates while hindering imports of slab zinc.

The U.S. Senate has passed Bill HR 7716 to amend the Tariff Schedules of the United States to suspend the duty on certain forms of zinc until the end of June 30, 1978. The Bill has been approved by the U.S. Congress and became law in August, 1975*. This temporary suspension of duty on certain forms of zinc, i.e. zinc ores and concentrates; zinc dross and skimmings; zinc bearing materials; and zinc waste and scrap, reduces the raw materials costs for the U.S. domestic zinc industry.

2.7.2 NON-TARIFF TRADE BARRIERS

Although the industrial strategies of EEC member countries support the continued growth of zinc smelting based on imported concentrates, it is difficult to point to specific governmental measures, other than the tariffs, which impede or could impede Canadian metal exports. One exception is the reported intention of the U.K. to subsidize, under its regional development program, the construction of a smelter by Cominco. The U.K., up to the present, is the only member of the EEC which is a major importer of zinc metal from Canada. The construction of a large new zinc refinery in the U.K. would significantly decrease their import requirements.

Similarly, it is very difficult to identify specific Japanese government measures, although administrative guidance may play a role in ensuring that Japan imports almost no zinc metal. More information is needed on the question of non-tariff measures in Japan.

The Japanese pricing system seems to be geared in favour of domestic metal producers. By means of a mechanism that is not entirely clear, the Japanese Producers' Price is "pegged" below a "managed" price for foreign imports, restraining effective price competition from imports.

A number of measures in the U.S. constitute an existing or potential impediment to Canadian metal exports to the U.S.A. These include: (a) U.S.A. anti-dumping practices, which do not include a meaningful test of injury, (b) government procurement, by which a foreign firm can compete for U.S.A. government contracts only if its prices are 6–12 percent lower than those of U.S.A. firms (which probably implies dumping in the case of zinc metal), (c) customs classification practices; for example, continuous cast zinc for remelting is classified as wrought rather than

*Import duty on zinc ores and concentrates, and zinc bearing materials suspended until June 30, 1978 as provided by P.L. 94-89.

unwrought if a hole is drilled in it to accommodate a safety chain.

2.7.3 OVERCOMING TRADE BARRIERS

Trade barriers are a constraint, in most cases probably a significant constraint, to further processing prior to export in the zinc sector. Activities constrained by trade barriers include metal production, die-casting, and certain miscellaneous processes including forgings and, potentially in the future, superplastic sheet and products manufactured from sheet. Other constraints, for example, include the marketing or disposal of sulphuric acid produced as a by-product of zinc metal, the cost of moving zinc die-castings over long distances, and the small scale of most existing Canadian die-casters. Canada should seek reduction of trade barriers to zinc and zinc products in the current multilateral negotiations. The General Agreement on Tariffs and Trade (GATT) negotiations will continue at least until late 1977.

TABLE 2.7.1

TARIFFS

	BRITISH PREFERENTIAL	MOST FAVOURED NATION	GENERAL
Canada			
Zinc in ores and concentrates	Free	Free	Free
Zinc smelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals, in the form of pigs, slabs, dust or granules/lb.	Free	Free	2¢
Zinc dross and zinc scrap for remelting, or for processing into zinc dust	Free	Free	10%
zinc anodes	Free	Free	10%
United States			
			(¢/lb)
Zinc ores and concentrates, on zinc content			0.67*
Unwrought zinc			
Other than alloys of zinc			0.7
zinc waste and scrap			0.75
zinc dross and skimmings			0.75
			(%)
			19
Alloys of zinc			
zinc anodes on and after January 1, 1970			13
1971			11
1972			9.5

	TARIFF RANGE AD VALORM (%) EQUIVALENT
Japan	
Ores and concentrates	0.0
Scrap (including alloys)	2.5
Refined (including alloys)	0.0-11.1
Semi-fabricated	7.5-15
Fabricated	7.5-10
E.E.C.	
Ores and concentrates	0.0
Scrap (including alloys)	0.0
Refined (including alloys)	3.5%
Semi-fabricated	6.0-10.0
Fabricated	7.0-8.0

* Duty on zinc ores, concentrates and zinc-bearing materials suspended until June 30, 1978 as provided by P.L. 94-89.

Chapter 3 Zinc Resources

A mineral resource is defined as a concentration of naturally occurring solid, liquid, or gaseous material in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Ore reserves are composed of specific bodies of mineral bearing material whose location, quality and quantity are known from geological evidence supported by engineering measurements and from which a usable mineral or energy commodity can be economically and legally extracted at the time of classification.

From the above, it is clear that ore reserves are only those small portions of mineral resources which are both well delineated and rich enough to be mined economically at this time. Other resources may be converted into reserves in two ways:

1) by finding new economically mineable mineral deposits, or by exploring extensions to known ones, and establishing size and quality to the standards of reliability specified for reserves.

   or

2) by the increase of metal prices or improvements in technology which convert previously uneconomic material into ore.

Conversely, decreasing prices or increasing taxes, labour costs or capital costs may convert ore back into waste.

A more complete description of the classification is given in Appendix "A".

A really thorough knowledge of the resource inventory of a given area would require the collection of data relating to all nine categories shown in the classification scheme. Such knowledge is neither practically nor even theoretically possible. For governmental and business policy making purposes, the four categories 1A, 1B, 2A and 2B are the only relevant ones. Speculative material in categories 3A and 3B ought to be there geologically speaking, but it may or may not be found. Similarly, low grade material that is unlikely to become ore within the planning horizon of existing firms, say the next 25 years (1C, 2C and 3C) is of only academic interest. These latter categories are not the stuff refineries are made of nor are they a source of export dollars.

The two-dimensional nature of the subject may be better appreciated by reference to the standard Ontario Mineral Resource Classification which is shown on page 157.

Published information regarding the four most important categories varies widely in both quantity and reliability. Fairly complete and reliable information is available only for category 1A, ore reserves, because these data, appearing in company annual reports, must meet certain standards, and must be provided for financing purposes, etc. Little is published regarding partly discovered economic and paramarginal mineral bodies (1B, 2A and 2B) although this material is likely to move into the reserves category in the foreseeable future and is therefore important for planning purposes.

The present analysis, which relies only on published information, entails a good deal of subjective judgment regarding categories other than reserves because of the lack of data.

ONTARIO MINERAL RESOURCE CLASSIFICATION

			← INCREASING CERTAINTY OF EXISTENCE			
			DISCOVERED RESOURCES		PARTLY DISCOVERED	UNDISCOVERED
			Known Deposits		Expected Additional (In Known Areas)	Speculative (In Unknown Areas)
			Proven	Probable	Possible	
			Measured	Indicated	Inferred	
INCREASING LIKELIHOOD OF BECOMING ECONOMICALLY MINEABLE WITHIN 25 YEARS ↑	Economic (now)		IA RESERVES		2A	3A
	100%					
	Sub – economic	Para — marginal	IB CONDITIONAL RESOURCES		2B	3B
	50%					
	Sub – economic	Sub – marginal	IC CONDITIONAL RESOURCES		2C	3C
	10%					

3.1 Ontario Zinc Resources

3.1.1 ZINC RESERVES (CATEGORY 1A)

The ore reserve tonnages and grades of Ontario zinc producing mines and properties being prepared for production are summarized in Table 3.1.1. The information is taken from company annual reports and is probably slightly on the conservative side as reputable companies are usually careful to avoid any suggestion of unwarranted optimism. Some variations in interpretation of the standard definitions for reserves (see Appendix "A") may occur, but studies of the methods used by the various companies indicate that these variations are of little practical significance.

Total Ontario zinc reserves at the end of 1975 were calculated to be 6.6 million tonnes of zinc contained in 118.6 million tonnes of ore. At a typical recovery of 85%, allowing for mining, milling and refining losses, the recoverable zinc would amount to about 5.6 million tonnes. Of this total, 70% is found at the Texasgulf mine at Timmins, 14% at the Geco and Willroy mines at Manitouwadge, 15% at the Mattabi, Lyon-Creek and Sturgeon Lake mines north of Ignace and 1% at the South Bay mine in the Uchi Lake area.

3.1.2 EXPECTED ADDITIONAL ECONOMIC RESOURCES (CATEGORY 2A)

As stated previously, published data on resources outside category 1A are incomplete. Texasgulf reports 6 million tonnes of inferred ore above the 853 metre level in the 1975 annual report and also states that twenty four diamond drill holes have intersected ore between the 853 and 1524 metre levels. The zinc content of the ore decreases at these lower levels, however, and the copper content rises. Thus, Texasgulf ore mined to date from the open pit and upper levels of the mine has averaged 9.50% zinc while data given in the 1973 annual report indicates an average zinc grade of about 3% at the 853 metre level. From this, and other published data for Texasgulf, a very rough estimate of inferred zinc content can be made. Little information regarding inferred resources in the economic category is available for the other Ontario orebodies but their geological origin is such that continuity of the orebody between widely spaced holes cannot be safely assumed, nor can ore be assumed to continue far beyond the limits of discovered, i.e. drilled off, areas. Inferred tonnages are therefore likely to be relatively small.

Because of the lack of information, any figure for inferred economic resources for the Province of Ontario can be no better than an educated estimate based on geological knowledge and such data as is available. A total of 2 million tonnes of contained zinc is likely to be approximately correct. A variation from this figure of plus or minus 50% is entirely possible.

The majority of the additional zinc is estimated to be present in the larger deposits. Its presence would, therefore, have the effect of substantially extending the life of the related mines rather than increasing the zinc production of the province in the shorter term. Accurate figures for the inferred category would be of considerable significance in any study of possible future zinc production in Ontario. A detailed provincial inventory of zinc reserves and resources is under way but the information obtained will not be available for publication, due to the confidentiality of the data.

Little is published regarding those resources in Category 2A which do not meet the "inferred" standard of reliability. From consideration of the geology of the orebodies, however, it is unlikely that this category would be of much practical significance.

3.1.3 PARA-MARGINAL DISCOVERED RESOURCES (CATEGORY 1B)

These are discovered resources not at present economically mineable but which have a reasonable feasibility of being mined in the next 25 years due to improved metal prices or technology. The geology at the producing mines is such that the change from good ore to waste is quite sharp so that the amount of para-marginal material is relatively small. As in the case of inferred resources, an educated estimate can be made for the province. This para-marginal material would be no better than 10% of the provincial reserves or about 600 000 tonnes of contained zinc.

A number of properties not in production also contain para-marginal resources. The published figures for each property are shown in Table 3.1.3 along with the figures for similar properties having resources in Category 2B. Inferred resources are noted but lack of this notation does not necessarily mean that the remainder meet the standards of reliability for Category 1B. It can be seen that there are no large zinc properties known in Ontario which could come into production under more favourable economic conditions and that there are only two deposits of even significant size. It is not considered likely that further investigation of these properties would substantially change the situation. The Category 1B content of the properties listed in Table 3.1.3 is unlikely to be more than 700 000 tonnes of contained zinc, at best, so that a provincial total of 1.3 million tonnes (plus or minus 50%) in this category seems a reasonable estimate.

3.1.4 EXPECTED ADDITIONAL PARA-MARGINAL RESOURCES (CATEGORY 2B)

Little information is available on this category for the producing mines but, for the geological reasons mentioned earlier, the category is not considered significant as regards zinc in Ontario. Some inferred para-marginal material, totalling roughly 100 000 tonnes of contained zinc, is listed in Table 3.1.3.

3.1.5 SPECULATIVE RESOURCES (CATEGORY 3A AND 3B)

Data used in speculative resource estimation are principally those derived for use in strategic land use planning studies. These figures are essentially estimates of the relative probability of occurrence of mineral deposits in areas of the province and are not intended for use in absolute terms. Similarly they are only an indication of what zinc might be present and in no way indicate when it will be found or even that it will be found at all.

The data shown in Table 3.1.4 do however, indicate that, on the basis of present knowledge of the geology of Ontario and its ore deposits, large quantities of zinc in numerous deposits could be mined under existing or anticipated economic conditions within the next 25 years, if found. Although additional knowledge and refinement in method-

ologies of calculation might result in a reduction of the overall figure, it is considered that Ontario has a potential for new zinc deposits with reserves significantly higher than presently measured reserves.

The method of calculation was for favourable rock types to be defined in areas of known zinc deposits and an average value per square mile to be assigned to these. The values were then applied to other areas of favourable rock throughout the province.

3.1.6 SUB-MARGINAL RESOURCES (CATEGORIES 1C, 2C AND 3C)

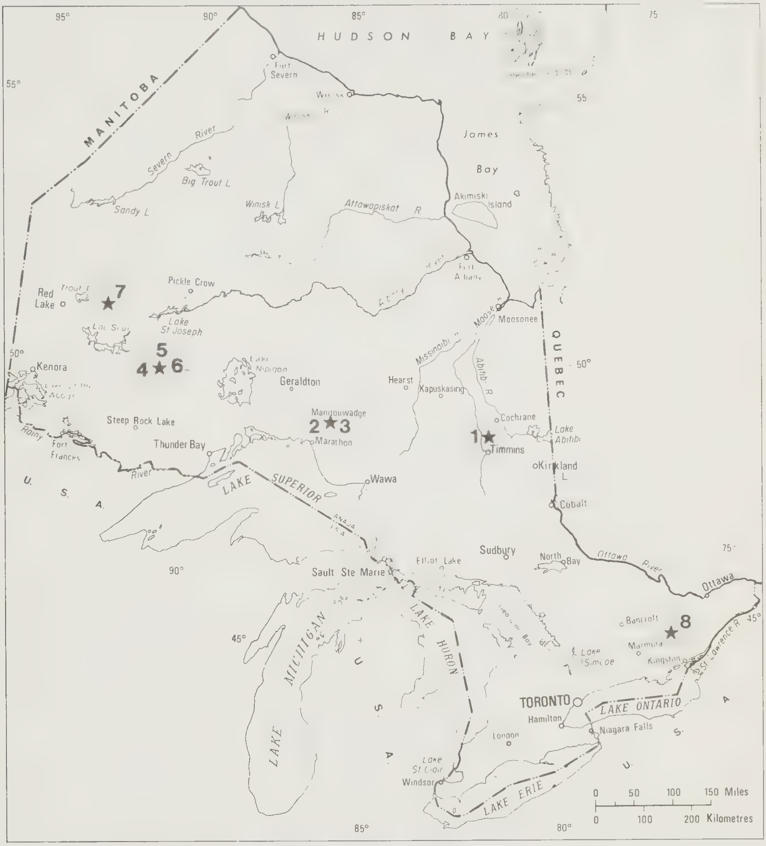
Because of the nature of occurrence of zinc deposits within Ontario, no reasonable assessment of zinc resources can be made for this category and no figure is assigned to it. The principal zinc bearing deposit type of Ontario is the volcanogenic massive sulphide type. Numerous other massive sulphide deposits have been recognized but their low grade has not warranted sufficient exploration work to determine tonnage and grades.

3.1.7 SUMMARY

It has been shown that the known zinc reserves of Ontario will not be increased substantially from known deposits as a result of more favourable economic conditions. Inferred economic resources, which can be converted into reserves by more detailed exploration, are limited. Estimates have been made that a substantial quantity of additional, although as yet undiscovered, potentially mineable zinc is present within Ontario. No estimates have been made, however, of the discovery rate of new deposits within a specific time period, or of the extent to which Ontario's zinc reserves will be increased by new discoveries. These factors are of particular significance in any study of the outlook for zinc in Ontario during the next 25 years. Such predictions cannot be made, but certain features can be noted. Figure 3.1.2 shows the yearly known zinc reserves of Ontario over the last 25 years; it can be seen that in this time period they have increased from virtually zero to their present level, despite the production during this period of approximately 3 million tonnes of zinc. This increase may be equated in part with the advent of sophisticated airborne geophysical techniques and it could be suggested that, as all the "favourable" areas have been investigated, few, if any, additional discoveries might be expected. While discovery is a function of factors such as exploration effort, increase in depth of penetration of geophysical instruments and development of new exploration techniques, it is considered that there is a good probability of new discoveries being made within the next 25 years. No estimate is made, however, of numbers, tonnage or grades.

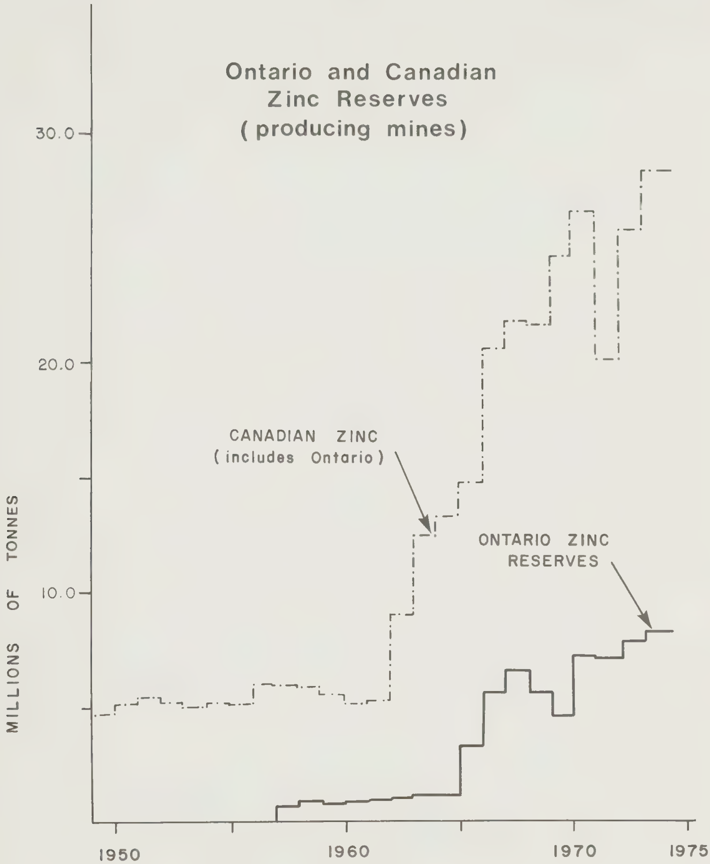
Economic Zinc Deposits of Ontario

FIGURE 3.1.1



1. Kidd Creek Mine
2. Geco Mine
3. Willroy – Willecho
4. Mattabi Mine
5. Lyon Lake Deposit
6. Sturgeon Lake Mine
7. South Bay Mine
8. Long Lake Mine

Figure 3.1.2



Zinc reserves in Canada and in Ontario for 1949 — 1973. These reserve figures, taken from the Canadian Mines Handbook, are for producing mines only.

TABLE 3.1.1

PROVEN PLUS PROBABLE ORE RESERVES OF PRODUCING ONTARIO ZINC MINES (RESOURCE CATEGORY 1A)

COMPANY DEPOSIT & AREA	ORE (THOUSAND TONNES)	GRADE % ZINC	ZINC CONTENT (THOUSAND TONNES)	Cu %	Pb %	Au g PER TONNE	Ag g PER TONNE	OTHER
Texasgulf Canada Kidd Creek Timmins	78,017	5.92	4,619	2.70	0.21		79.21	Cadmium Tin
Noranda Mines Geco Manitouwadge	25,492	3.62	923	1.87			52.12	
Willroy Mines Willroy-Willecho Manitouwadge	529	3.91	21	0.47	0.16		52.81	
Mattabi Mines Mattabi Sturgeon Lake	8,981	6.70	602	0.74	0.70		89.84	
Mattagami Mines Lyon-Creek Sturgeon Lake	3,656	6.66	243	1.15	0.63	0.34	116.24	
Sturgeon Lake Sturgeon Lake Sturgeon Lake	1,637	10.28	168	2.85	1.36	0.75	194.08	
Selco Mining South Bay Uchi Lake	293	12.45	36	1.95			103.56	
TOTALS	118,605	5.57	6,612					

SOURCE: From best published data available in April, 1976

TABLE 3.1.2

ONTARIO ZINC
RESERVES AND INFERRED ECONOMIC RESOURCES
OF KNOWN DEPOSITS

	10^3 TONNES OF ZINC CONTENT	ESTIMATED RELIABILITY
RESERVES:	6,600	± 10%
INFERRED ECONOMIC RESOURCES	2,000	± 50%
TOTAL (RESERVES AND INFERRED ECONOMIC RESOURCES)	8,600	

N.B. The above figures are summed only to give a rough picture of the resources reasonably likely to be available in the economic category. The inclusion of inferred material in reserves for the purpose of cost and feasibility studies is not acceptable. On the other hand, it would be unrealistic to ignore such resources completely.

TABLE 3.1.3

ONTARIO PRINCIPAL PARAMARGINAL ZINC DEPOSITS

		GRADE							
COMPANY	10^3 TONNES OF ORE	Zn.	Cu.	Pb.	Au.	Ag.	10^3 TONNES ZINC CONTENT	RESERVE STATUS
Cam Mines	142	5.17	.24				7	IND
	45	4.79					2	INF
Trout Bay	12	4.75	.68			.94	1	
(Cochenour)	11.3	7.86	1.5	.024		1.70	9	
Consolidated Shunsby	318	1.3	1.2				4	
Copper Lode	307	4.36	.60			.40	13	
	250	4.80	.66			.39	12	
	95	7.39	.98			.62	7	
Excelsior	45	4.02		2.04			2	
Geneva Lk.	103	10.0		3.00			10	
	51	5.0					3	INF
Giant Yellowknife Errington Mine	10,768	3.91	1.09	1.09	.021	1.66	421	
Giant Yellowknife Vermillion Lk.	5,389	3.89	1.13	1.02	.024	1.43	210	
Hannam	32	9.10		19.9		27.6	3	IND
	33	9.10					3	INF
Harrison	363	1.69	2.09				6	INF
	181	1.63	1.98				3	INF
Headvue	541	2.00		1.15			11	INF
Kendon Copper	242	4.76	1.45			28.0	12	IND
Marshal Lake	454	3.80	1.02		.006	2.13	17	
Stralok	330	3.18	0.32			0.68	11	
Zahavy	544	2.99		2.06	.18	7.81	16	
TOTAL							782	

IND = Indicated
INF = Inferred

TABLE 3.1.4

ONTARIO POTENTIAL ZINC RESOURCES

GEOLOGICAL AREA		10^3 TONNES OF ZINC CONTENT
ARCHEAN:	NORTHEAST	12,205
	NORTHWEST	27,066
SOUTHERN		758
GRENVILLE		27
TOTAL		40,056

3.2 Canadian Zinc Resources

The published reserves of the principal zinc producing mines of Canada are summarized in Table 3.2.1 and shown in Figure 3.2.1. Without detailed knowledge of each of these deposits a realistic estimate of additional economic resources cannot be made; (an inferred-to-measured ratio similar to or lower than that of the Ontario deposits might be reasonable).

Within Ontario the para-marginal zinc resources of known deposits equalled less than 20% of the measured zinc reserves of the province.

Principal para-marginal deposits of Caanda are shown in Table 3.2.2 and are estimated at 9.3 million tonnes of zinc content.

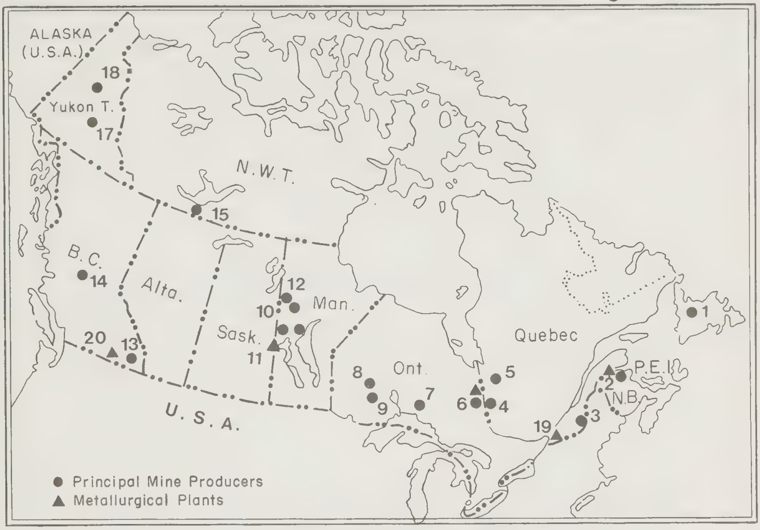
3.3 World Zinc Resources

The only readily available comprehensive data on world zinc resources are those published recently by the United States Geological Survey. The classification scheme used varies somewhat from the Ontario scheme, principally in the inclusion of "possible" ore in the reserve category.

The estimated world zinc resource figures are shown in Table 3.3.1 and a breakdown of identified reserves by continent in Table 3.3.2 with approximate subdivision of North America is included. The estimate for Canada is approximately equal to that suggested in this report.

Canada is presently producing approximately 29% of the world's zinc and contains only 15.5% of the world's identified zinc reserves.

Figure 3.2.1



ZINC PRODUCERS IN CANADA

● Principal Producers

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Brunswick Mining and Smelting Corporation Limited
   Heath Steel Mines Limited, Anaconda Canada Limited
3. Sullivan Mining Group Ltd.
4. Falconbridge Copper Limited, Lake Dufault Division
   Manitou-Barvue Mines Limited
   Kerr Addison Mines Limited (Normetal mine)
5. Mattagami Lake Mines Limited
   Orchan Mines Limited
6. Texasgulf Canada Limited
   Kam-Kotia Mines Limited
7. Noranda Mines Limited (Geco mine)
   Willroy Mines Limited
8. Selco Mining Corporation Limited
9. Mattabi Mines Limited
10. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Dickstone, Ghost Lake, Anderson Lake, White Lake)
11. Hudson Bay Mining and Smelting Co., Limited (Flin Flon, Schist Lake)
12. Sherritt Gordon Mines, Limited (Fox Lake mine and Ruttan mine)
13. Cominco Ltd., (Sullivan mine and H.B. mine)
    Teck Corporation Limited (Beaverdell mine)
    Reeves MacDonald Mines Limited (Annex mine)
    Kam-Kotia-Burkam Joint Venture (Silmonac mine)
14. Bradina Joint Venture
15. Western Mines Limited
16. Pine Point Mines Limited
17. Anvil Mining Corporation Limited
18. United Keno Hill Mines Limited

▲ Metallurgical Plants

19. Canadian Electrolytic Zinc Limited, Valleyfield
11. Hudson Bay Mining and Smelting Co., Limited Flin Flon
20. Cominco Ltd., Trail
6. Ecstall Mining Limited

Source: EMR's Annual Review

TABLE 3.2.1

ZINC RESERVES OF CANADA

PROVINCE	PRINCIPAL ZINC PRODUCING MINES	10^3 TONNES ZINC CONTENT
NEWFOUNDLAND	Buchans	174
NEW BRUNSWICK	Brunswick #6 (proven)	5,459
	(probable)	1,915
	Heath Steel	1,706
	Nigadou River	40
QUEBEC	Lake Dufault	89
	Joutel Copper	14
	Normetal	6
	Manitou Barvue	31
	Mattagami Lake	1,075
	Orchan Mines (Orchan, Garon, Norita)	245
	Cupra-D'Estrie	23
	Louvem	4
MANITOBA – SASKATCHEWAN	All HBM & S (ore)	474
	(tailings)	339
	Sherrit – Fox	230
	– Ruttan	713
BRITISH COLUMBIA	Sullivan (Aggregate Cominco)	2,983
	Silmonac	24
	Western Mines Limited	120
YUKON	Anvil	2,830
	United Keno	1
NORTH WEST TERRITORIES	Pine Point	2,085
TOTAL CANADA (EXCLUDING ONTARIO)		20,580
ADD: ONTARIO (See Table 3.1.1)		6,612
TOTAL CANADA		27,192

TABLE 3.2.2

CANADIAN
PRINCIPAL PARAMARGINAL DEPOSITS OF ZINC

PROVINCE	COMPANIES	10^3 TONNES OF ZINC CONTENT
NEWFOUNDLAND	Daniels' Harbour	416
NEW BRUNSWICK	Caribou	2,215
	Chester	379
	Key Anacon	114
	Teck	192
NOVA SCOTIA	Gays River	864
SASKATCHEWAN	Bison	192
YUKON	H.B.M. & S	726
	Kerr	237
	Vangorda	466
NORTH WEST TERRITORIES	Arvik	2,500
	Bankeno	130
	Buffalo	130
TOTAL CANADA (EXCLUDING ONTARIO)		8,561
ADD: ONTARIO (See Table 3.1.3)		782
TOTAL CANADA		9,343

TABLE 3.3.1

WORLD ZINC RESOURCES

	IDENTIFIED RESOURCES	UNDISCOVERED RESOURCES	TOTAL
	MILLIONS OF TONNES ZINC CONTENT	MILLIONS OF TONNES ZINC CONTENT	MILLIONS OF TONNES ZINC CONTENT
Recoverable	235	345	580
Sub Economic	1,275	3,230	4,505
TOTAL	1,510	3,575	5,085

TABLE 3.3.2

RECOVERABLE WORLD ZINC RESERVES

			10^3 TONNES OF ZINC CONTENT
NORTH AMERICA:	U.S.A.		45
	CANADA		33
	MEXICO		6
		TOTAL	84
SOUTH AMERICA			16
EUROPE			58
AFRICA			14
ASIA			42
AUSTRALIA			21
TOTAL			235

Chapter 4

Developments in the Zinc Industry

The recent developments in the Free-World zinc industry are discussed under two major Sections: Ore and Concentrates, and Slab Zinc.

In presenting data on the new mine and plant capacities, the approach followed in this section was to include all announced projects without the exercise of personal judgement. Since the status of announced projects changes rapidly, the data is sensitive to the cut-off date and requires further revision on a continuous basis. The information presented in this section is current up to March, 1976. Projection of mine and plant capacities, compiled by others may differ according to the cut-off date for the data and the application of subjective judgement in assessing the probability of a project being completed as announced.

4.1 Zinc Ore and Concentrates

Zinc is generally found in association with lead or copper, or both, with zinc as the predominant metal. In Ontario, zinc is found in association with copper and silver, which are produced as co-products. The Ontario ores also contain cadmium, lead and on occasion tin in commercially significant quantities.

Decisions regarding zinc production are influenced, therefore, not only by the price and market for zinc, but by the market conditions for other constituents, especially copper, silver and cadmium. A zinc deposit which may not be economical on the basis of zinc alone may be viable on the strength of the associated metals in the ore. Other factors affecting zinc production include:

- government policies towards assistance, exploration, exploitation, infrastructure, mineral taxation and environmental restrictions;
- capital availability and investor attitude;
- attitudes of organized labour.

The existing and planned capacities for zinc ore and concentrates are adequate to meet the required demand until 1979. The top six ore producing countries are likely to share the major growth and continue to maintain over 70% of the Free World output. Table 4.1.1 provides a detailed breakdown of additions and closures of zinc ore and concentrate production capacity, by plant and country, in the Free World covering a period from 1973 to 1979.

Table 4.1.2 summarizes the planned increases in zinc mine output. Assuming that all projects commence on schedule, the total increase of 1 842 120 tonnes of net new mine production capacity is estimated to be installed in the period from 1973 to 1979. This represents a compound growth rate of 5% per annum. Europe leads in the growth of zinc mining capacity with an increase of 530 000 tonnes of zinc between 1973 and 1979. Australia, Canada and the U.S., respectively follow with lower rates of growth in mine development in that period (see Table 4.1.2).

Major developments in zinc mining and concentrate production can be summarized as follows:

CANADA

In 1975, Sturgeon Lake Mines in Ontario and Newfoundland Zinc in Newfoundland commenced commercial production. The Lyon Lake Mine in Ontario and the Nanisivik Mine on Baffin Island, Northwest Territories, are expected to come on stream in 1977 or 1978. Texasgulf has announced a potentially significant deposit at Izok Lake, Northwest Territories. Kerr Addison/AEX Minerals Corporation continued to expand zinc-lead-silver reserves at the Grum deposit near Faro, Yukon Territory. Cuvier Mines in Nova Scotia and Arvik Mines in the Northwest Territories could be potential producers.

Developments in the Territories presently have the unique advantage of dealing with only one level of government, i.e. the Federal Government, in matters of taxation, but this may be offset by greater uncertainties arising from native land claims. Noranda recently announced a potentially economic zinc-copper deposit in the Goldstream River area, British Columbia.

THE U.S.A.

In the U.S., the New Jersey Zinc company and Union Minière of Belgium through a joint-venture will develop two zinc mines (in addition to the Elmwood zinc mine, brought into production in 1975) in Tennessee at a cost of $67 million. Callahan Mining Corporation and the New Jersey Zinc Company through a joint-venture will develop a zinc-copper deposit in North-central Virginia. Noranda has announced a potentially economic deposit in Oneida County, Wisconsin.

A Japanese consortium has joined Getty Oil in exploring for zinc in eastern Tennessee. Anaconda/Sunshine reported high grade intersections from drilling in the Ambler district, Alaska.

AUSTRALIA

Mine developments in Australia are at the St. Joe's Woodlawn Mine and the Hilton Mine. Other producers in Australia and Oceania are: the Placer Prospecting Tarrago Mine and Tycho Mining in Western Australia. North Broken Hill Limited disclosed very promising intersections while drilling adjacent to the existing North Broken Hill Mine.

EUROPE

The largest single development in Europe is that of Ireland's Navan deposit which is expected to commence production in 1977. The rated annual capacity of 200 000 tonnes of zinc in concentrate will be reached in 1978. The total capital costs for Tara's Navan project increased to $150 million from the original estimate of $60 million. Zinc concentrates from the Navan deposit will be marketed mainly in the United Kingdom, France, Belgium, West

Germany and Netherlands under long-term contracts. Noranda Mines and Cominco Limited of Canada own 20% and 17% equity interest respectively in Tara Exploration and Development Company of Ireland.

The Rubiales Mine in the Northern part of Spain is currently being developed by Cominco Limited and will be brought into production in 1977. Other developments in Spain include Piedrafita del Cebreso and Anduluza de Piritas.

Two mines in Sweden are expected to add 29 000–32 000 tonnes of zinc in concentrates per year by the end of 1977.

OTHER COUNTRIES

Two developments in India will add 60 000 tonnes of annual zinc capacity between 1976 and 1979.

In addition, small mines will be opened or expanded in Turkey, Algeria, Bolivia, Brazil, Honduras and Mexico.

Noranda, New Jersey Zinc and U.S. Steel have signed a joint-venture agreement covering further exploration of a zinc prospect in Minas Gerais, Brazil. The new prospect lies within a belt already containing two producing zinc mines.

4.1.1 CAPITAL COST FOR MINE DEVELOPMENT

A medium-sized mine with a capacity of 2000 tonnes of ore per day required $20 million in capital in 1970. This represented a capital cost of approximately $10 000 per tonne per day of mine output to the concentrator. Table 4.1.3 compares capital costs for recent mine/concentrator projects with those plants scheduled for completion by 1977.

Unit capital cost per tonne of ore per day increased from $15 000 to $26 000 per daily tonne in the period from 1972 to 1977. The final capital cost of projects now under construction may escalate beyond the currently estimated costs. These capital cost estimates do not include general exploration and discovery costs which can range between $20 and $35 million for finding a new commercial deposit.

TABLE 4.1.1

ZINC ORE AND CONCENTRATE PRODUCTION CHANGE*

(10^3 TONNES OF ZINC CONTENT)

COUNTRY	PROPERTY	TYPE	1973	1974	1975	1976	1977	1978	1979	TOTAL
CANADA	Cominco									
	H.B. Mines, B.C.	R.O.	15							
	Bradina Bralorne									
	Resources	C	–4							
	Sherritt Gordon									
	Rutton Lake, Man.	N	45							
	Quemont, Que.									
	Kerr Addison	C	–4							
	Nigadoo River Mines	R.O.		7						
	New Brunswick									
	Normetal									
	Kerr Addison, Que.	C		–12						
	Texasgulf Canada	E				15				
	Timmins, Ontario									
	Joutel Copper, Que.			–6						
	Sturgeon Lake Mines	N			30					
	Sturgeon Lake, Ont.									
	Mattagami, Lyon Lake	N					18			
	Reeve MacDonald, B.C.	C			–2					
	Hudson Bay M & S				4					
	Central Mines, Man.	N								
	Heath Steel									
	Little River, N.B.	E				14				
	Nanisivik									
	Baffin Island N.W.T.	N					76			
	Newfoundland Zinc									
	Daniels River, NFLD	N				41				
	Brunswick Mining, N.B.	E							41.5	
	TOTAL CANADA		52	–11	32	70	94	–	41.5	278.5

2. Thousand tonnes per year

TYPE = Type of change
E = Expansion of existing mine
N = New Mine
C = Closure of mine
R.O. = Re-opening

* Data Contained in this Table are current up to March, 1976.

TABLE 4.1.1 (cont'd)

ZINC PRODUCTION (10^3 TONNES)

COUNTRY	PROPERTY	TYPE	1973	1974	1975	1976	1977	1978	1979	TOTAL
U.S.A.										
	St. Joe Minerals Co. Brushy Creek	N	6							
	St. Joe Minerals Co. Balmat	E	40							
	New Jersey Zinc Elmwood	N		18						
	Clarksville, Tenn.								90	
	Anaconda/Asarco Park City, Utah	E	R.O.		16					
	Schumaker Blue Hill		54.6	4.3						
TOTAL U.S.A.			100.6	22.3	16	–	–	–	90	228.9

TYPE = Type of change
E = Expansion of existing mine
N = New mine
C = Closure of mine
R.O. = Re-opening

TABLE 4.1.1 (cont'd)

ZINC PRODUCTION (10^3 TONNES)

COUNTRY	PROPERTY	TYPE	1973	1974	1975	1976	1977	1978	1979	TOTAL
CENTRAL & SOUTH AMERICA										
Dominican Republic	Rosario Resources	N				15				
Guatemala	Ipaco Industries	N		10						
	Tormen	N						6		
Mexico	CIA Fresnillo		FIGURES NOT AVAILABLE							
	El Monte	N								
Bolivia	Cumibol Matilda Mine	E		18						
	New Jersey Zinc	N					25			
Brazil	CIA Miniera De Metais Vazantes	E		8						
Peru	Homestake Mining-Madrigal	N	6							
	CIA Miniera Santa Loisa	E		10						
	Gran Bretana Mining	E		5						
	CIA Miniera Milpo	E			39.4					
	Anta Mina	N				39.3				
TOTAL CENTRAL & SOUTH AMERICA			6	51	39.4	54.3	25	6	–	181.7

TYPE = Type of change
E = Expansion of existing mine
N = New mine
C = Closure of Mines
R.O. = Re-opening

TABLE 4.1.1 (cont'd)

ZINC PRODUCTION (10^3 TONNES)

COUNTRY	PROPERTY	TYPE	1973	1974	1975	1976	1977	1978	1979	TOTAL
EUROPE										
Ireland	Tara Explorations	N	(Delayed by Irish Government)				200			
Austria	Blei-Berger-Beroweric-Union	E			7					
Denmark	Greenex Black Angel	N		85 (Greenland)						
France	Penarroya Sant Salvy	N				25				
Spain	Asturiana De Minas Huelva	N			8					
	Andaluza De Piritas Espanoles	N					65			
	Aipsa, Huelva	N				16				
	Piedrafita Del Cebrero	N				60				
	Rubiales	N					72.3			
Sweden	Vielle Montagne Ammeber	E					20			
	Boliden AB Stenkenjokk	N					9			
		C		–17.7						
W. Germany	Metallgesellschaft Ramsbeck	C		–20						
TOTAL EUROPE			–	47.3	15	101.0	366.3	–	–	529.6

TYPE = Type of change
E = Expansion of existing mine
N = New Mine
C = Closure of mine
R.O. = Re-opening

TABLE 4.1.1 (cont'd)

ZINC PRODUCTION (10^3 TONNES)

COUNTRY	PROPERTY	TYPE	1973	1974	1975	1976	1977	1978	1979	TOTAL
ASIA										
India	Hindustan Zinc Balaria	E		12						
	Hindustan Zinc Rajpura, Dariba	N				50				
	Hindustan Zinc Zawar					10				
Japan	Dowa Mining Fukazama	E			19					
	Dowa Mining Kosaka	E			20					
	Nippon Mining Tashiro Mine	C	–4							
	Toho Zinc Taishu	C	–4							
Thailand	Thai Zinc	N		30						
Phillipines	Zambales Base Metals	N		31.4						
TOTAL ASIA			–8	73.4	39	60	–	–	–	164.4

TYPE = Type of change
E = Expansion of existing mine
N = New Mine
C = Closure of mine
R.O. = Re-opening

Thousand tonnes per year.

TABLE 4.1.1 (cont'd)

ZINC PRODUCTION (10^3 TONNES)

COUNTRY	PROPERTY	TYPE	1973	1974	1975	1976	1977	1978	1979	TOTAL
AFRICA										
Africa (S.W.)	Anglo Transvall Prieska Mine	E			18					
Algeria	Sonarem Al Abed	E	R.O.		46					
	Algeria Govt.	N					10			
Kenya	Kinagoni Hill	N	0.72	(increasing later)						
TOTAL AFRICA			0.72	–	64	–	10	–	–	74.72
YUGOSLAVIA	Trepca Blagodat					24				
	Trepca Breskovo					24				
TOTAL YUGOSLAVIA			–	–	–	48	–	–	–	48
TURKEY	Cinkur Zamantiz	N				20				20
IRAN	Anguran	E					25			25

TYPE = Type of change
E = Expansion of existing mine
N = New Mine
C = Closure of Mine
R.O. = Re-opening

Thousand tonnes per year.

TABLE 4.1.1 (cont'd)

ZINC PRODUCTION (10^3 TONNES)

COUNTRY	PROPERTY	TYPE	1973	1974	1975	1976	1977	1978	1979	TOTAL
AUSTRALIA	St. Joe Minerals Co. Woodlawn Mine	N					50			
	Hilton Mine	N				241.3				
	Tarrago Mine	N	PRODUCTION STARTS IN 1975. FIGURES NOT GIVEN							
	Beltana Mine (EZ Industries)	N	PRODUCTION STARTS IN 1974-75. FIGURES NOT GIVEN							
TOTAL AUSTRALIA			–	–	–	241.3	50	–	–	291.3

TYPE = Type of change
E = Expansion of existing mine
N = New mine
C = Closure of mine
R.O. = Re-opening

Thousand tonnes per year

* Data contained in this Table are current up to March, 1976.

TABLE 4.1.2

FREE WORLD ZINC ORE AND CONCENTRATE PRODUCTION INCREASE *
(THOUSAND TONNES OF ZINC CONTENT)

REGION	1973	1974	1975	1976	1977	1978	1979	TOTALS (BY REGION)
CANADA	52	–11	32	70	94	–	41.5	278.5
UNITED STATES	100.6	22.3	16	–	–	–	90	228.9
CENTRAL AND SOUTH AMERICA	6	51	39.4	54.3	25	6	–	181.7
AFRICA	0.72	–	64	–	10	–	–	74.72
EUROPE	–	47.3	15	101.0	366.3	–	–	529.6
TURKEY	–	–	–	20	–	–	–	20
YUGOSLAVIA	–	–	–	48	–	–	–	48
IRAN	–	–	–	–	25	–	–	25
ASIA	–8	73.4	39	60	–	–	–	164.4
AUSTRALIA NEW ZEALAND	–	–	–	241.3	50	–	–	291.3
TOTALS	151.32	183.0	205.4	594.6	570.3	6	131.5	1,842.12

* Data contained in this Table are current up to March, 1976

TABLE 4.1.3

CAPITAL COST FOR MINE DEVELOPMENT*

YEAR OF COMPLETION	COMPANY	LOCATION	MINE CAPACITY ORE t/d	CAPACITY CONCENTRATE TONNES Zn/Yr.	TYPE OF OPERATION	CAPITAL COST $ MILLION	UNIT CAPITAL COST $/t/d (ORE)	REMARKS
1972	Mattabi Mines	Sturgeon Lake, Ont.	2,772	102,000	Open-Pit	41.	$15,062.	mine and concentrator no infrastructure
1973	Greenex	Greenland	1,650	85,000	U/G	44	$26,666.	mine and concentrator including infrastructure
1974	Sturgeon Lake Mine	Sturgeon Lake, Ont.	1,090	34,300	Open-Pit	20	$18,349	mine and concentrator no infrastructure
1975	Newfound-land Zinc	Newfound-land	1,360	41,000	Open-pit & U/G	18E	$13,235	exclusive of prior exploration and development cost
1977	Tara	Naven Ireland	6,800	200,000	Open-Pit	150	$22,060	Europe's largest zinc producer
1977	Exminesa	Rubiales Spain	2,000	72,300	U/G	52E	$26,000	

U/G – Under Ground
E – Estimate

* Data contained in this Table are current up to March, 1976

4.2 Zinc Refining Plants

4.2.1 ZINC PLANT CLOSURES

A critical shortage of zinc refining capacity was experienced in the Free-World zinc industry during the 1972-1974 period. Table 4.2.1 shows the list of closures of zinc refining plants. Several zinc refining plants in the United States, representing approximately 690 000 tonnes of slab zinc annual capacity were phased out between 1969 and 1975. This represents a drop of 55% in the total U.S. capacity of 1 245 586 tonnes of slab zinc that was available in 1968. These closures were mainly due to uneconomic, obsolete plants, aided by the cost-price squeeze and stringent pollution standards.

The European zinc industry lost 211 000 tonnes of zinc refining capacity during the 1973-1975 period.

4.2.2 PLANNED ZINC PROJECTS

The reduced U.S. slab zinc capacity has been mostly offset by the addition of productive capacity in other parts of the Free-World. Table 4.2.2 presents detailed data on planned zinc refining projects and indicates that a total planned capacity of 1.9 million tonnes of slab zinc will be added between 1973 and 1979. The European zinc industry leads the expansion with an addition of 535 000 tonnes, followed by the U.S. with 295 000 tonnes, if the new electrolytic zinc refinery (in Tennessee) is completed in 1979. South America ranks third in the planned expansions with 291 200 tonnes and is followed by Mexico with 208 700 tonnes planned by the end of 1979. Canadian expansion of slab-zinc capacity represents an increase of a mere 73 000 tonnes in the 1973-1979 period.

Undue delays in commencement of production could result in a deviation from the estimated capacity. All new zinc projects built in the Free World are electrolytic zinc plants with the exception of two European plants – one in Italy and the other in Yugoslavia – (accounting for 120 000 annual tonnes of zinc) which will employ the Imperial Smelting Furnace (ISF) process. The Indian plant at Rajasthan with a 100 000 tonne capacity will use either the ISF or the Electrothermic process. Relative advantages and disadvantages of these processes are described in the section "Technological Impact".

4.2.3 CAPITAL COSTS FOR REFINING PLANTS

The capital cost for a zinc refining complex depends largely on geographic location, material and construction costs, necessary ancillary facilities and infrastructure requirements. Inclusion or exclusion of the following items from the capital cost figures would make a great difference in the final total cost:

i) interest during the construction period,
ii) allowance for escalation of costs,
iii) environmental standard requirements,
iv) start-up expenses,
v) initial working capital required for process investories,
vi) direct and indirect government grants.

The capital cost of a project also varies with the inclusion or exclusion of the engineering and development costs, the process design used, eg. the Jarosite process (or equivalent) and mechanical handling systems for stripping of cathodes. Patent and licence fees for these facilities in a zinc plant can increase capital costs but improve the efficiency of operations.

Table 4.2.3 summarizes capital costs for 10 zinc plants (new and expansions) built or to be built during the period from 1963 to 1979. These examples demonstrate the dramatic escalation in capital costs. Figure 4.2.1 shows the comparison of unit cost per tonne of annual capacity. However, it is misleading to compare these unit costs without taking into consideration the above factors and all the complexities involved in building a zinc plant.

Any capital cost comparison of projects should be approached with great caution due to the diversity caused by the inclusion or exclusion of the items mentioned above in the final cost figures. To cite an example, the first stage of the Canadian Electrolytic Zinc plant, completed in 1963 at a cost of $16 million (i.e. $210 per tonne of annual capacity) excluded roasting facilities and major infrastructure. In 1973, CEZ announced its expansion from 131 500 tonnes to 204 000 tonnes of annual capacity. The estimated expansion cost of $30–$33 million increased to $61 million on completion in 1975. This is equivalent to a unit cost of $840 per annual tonne of expanded capacity.

The New Jersey Zinc Company and Union Minière S.A. of Belgium have announced a joint-venture project to build the first new zinc refinery in the United States since 1941. The proposed electrolytic zinc refinery will have an annual capacity of 81 650 tonnes of slab zinc and will be built at Clarksville, Tennessee. Capital costs are estimated at $97 million and will require an additional $15 million for working capital. The unit cost of this refinery will be $1372 per tonne of installed capacity.

The National Zinc Company will be opening its new 50 000 tonne capacity refinery in mid-1976. This facility was built to replace their obsolete horizontal retort plant (45 000 tonne annual capacity) which is being closed during 1976.

Cominco completed a feasibility study for the construction of a zinc refinery in The United Kingdom with an annual capacity of 100 000 tonnes and estimated to cost $110 million, or $1100 per annual tonne. This capital cost does not include the receipt of U.K. government construction grants. However, Cominco deferred a decision to proceed with this project due to present economic conditions in the United Kingdom. The final capital cost of this project, on completion, will be undoubtedly entirely different and inflated from the estimated figure.

Four groups, Brazilian, Spanish, Belgian and British have formed a new firm, Companhia Paraibuna de Metals, to build a 30 000 annual tonne electrolytic zinc refinery in Brazil. The four companies and their respective interests in the project are: the Brazilian Company Torquato S.A., 60%; Austuriana de Zinc, 18%; Union Minière, S.A., of Belgium, 18%; and AMC Limited, 4%. The total cost of the plant is estimated at $45 million (or $1500 annual tonne capacity). The National Development Bank (BNDE) has agreed to finance 60% of the cost. Initial production is scheduled for mid-1978. It is currently believed that Australian, Mexican or Peruvian zinc concentrate can be imported.

Initial cost estimates for the first zinc refinery in South Korea are $55 million for a 50 000 tonne per year refinery.

This plant is expected to start in late 1977, and is designed for second stage expansion to 100 000 tonnes per annum.

The Irish government has recently invited 40 zinc refining firms throughout the world to submit bids for construction of a new zinc refinery in Ireland. The refinery will have an annual rated capacity of 100 000–150 000 tonnes of zinc, making it one of the largest in Europe. This zinc plant will use concentrates from the Tara and Bula mines near Navan. The refinery is projected to cost in excess of £55 million; the Irish government will contribute 5%–7% of the total, although it reportedly intends to acquire at least 10% equity interest in the refinery. Profits from the refinery will be tax-free until 1990. Plans are currently scheduled to be finalized by March 31, 1977.

4.2.4 OPERATING COSTS OF REFINERIES

Estimates of capital and operating costs indicate that the minimum economic size for an electrolytic zinc plant is about 110 000 tonnes of zinc metal per year. Table 4.2.4 provides the labour, maintenance and supervision costs for operating an electrolytic zinc plant with 110 000 tonnes of annual capacity. Table 4.2.5 summarizes total production costs, including consumption of utilities, operating and maintenance materials, spare parts and labour costs. The total production cost of \$153 per tonne of slab zinc or 6.9¢/lb. is based on average estimated costs, effective December, 1974.

The estimated production cost excludes interest charges, depreciation, insurance, general and administrative costs, royalties and contingencies. However, the extent of some of these costs is indicated in Table 4.2.6. Interest and capital costs are spread over a 15-year period. The total cost, including only interest and depreciation costs, amount to \$253 per tonne of annual capacity of slab zinc or 11.5¢/lb.

The total production cost of 11.5¢/lb. of zinc is equivalent to a custom or toll charge of \$137 per tonne of concentrate with an average zinc content of 54%. If an average after-tax rate of return of 15% on capital investment (with an effective tax rate of 50% on income before taxes) is required, then the custom or toll charge to treat zinc concentrate should be in the order of \$300 per tonne of concentrate grading 54% zinc, or 25¢/lb. of zinc. At the present time, custom or toll charges are negotiated with an escalation clause which allows charges to be raised or lowered in accordance with changes in the published price of zinc. Cost increases in fuel, power, labour and pollution control are not normally directly passed on to the concentrate supplier via the treatment contract. The custom treatment charges are not quoted in a single currency, i.e. dollars, pounds or yen. It is believed that the custom treatment charges for zinc ranged from \$110 to \$130 per tonne of concentrate during 1974-75. The current (1976) range is from \$120 to \$145. This represented a substantial increase from \$65–\$85 per tonne of concentrate during the 1971-1973 period. These charges have remained proportional to the value of the payable metal in the concentrate. In mid 1974, the Akita Zinc Company, jointly owned by six Japanese smelters, increased smelting and refining charges by Y18 000 to Y56 000 per tonne (\$190/t) of zinc concentrate for the period June to November, 1974. This was an increase from Y38 000 or \$129 per tonne. A further increase was announced to Y62 000 or \$211 per tonne of concentrate, effective December, 1974.

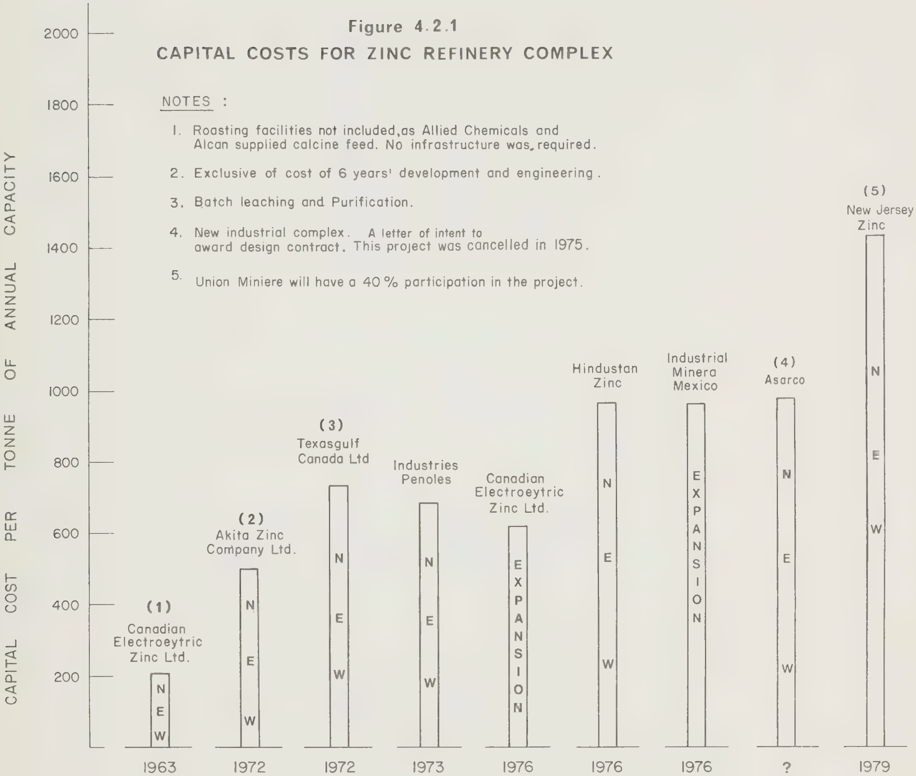


Figure 4.2.1
CAPITAL COSTS FOR ZINC REFINERY COMPLEX
NOTES :
1. Roasting facilities not included, as Allied Chemicals and Alcan supplied calcine feed. No infrastructure was required.
2. Exclusive of cost of 6 years' development and engineering.
3. Batch leaching and Purification.
4. New industrial complex. A letter of intent to award design contract. This project was cancelled in 1975.
5. Union Miniere will have a 40 % participation in the project.
CAPITAL COST PER TONNE OF ANNUAL CAPACITY
2000
1800
1600
1400
1200
1000
800
600
400
200
(1) Canadian Electroeytric Zinc Ltd.
(2) Akita Zinc Company Ltd.
(3) Texasgulf Canada Ltd
Industries Penoles
Canadian Electroeytric Zinc Ltd.
Hindustan Zinc
Industrial Minera Mexico
(4) Asarco
(5) New Jersey Zinc
NEW
EXPANSION
1963
1972
1972
1973
1976
1976
1976
?
1979

TABLE 4.2.1

CLOSURE OF ZINC REFINING PLANTS *

LOCATION	COMPANY	TYPE OF PLANT	ANNUAL CAPACITY TONNES	YEAR OF CLOSURE	REMARKS
U.S.					
Montana	Anaconda	E	81,648	1969	
Oklahoma	Eagle Picher	H.R.	49,900	1969	
Illinois	American Zinc	E	76,200	1971	
Texas	American Zinc	H.R.	52,618	1971	
West Virginia	Mathiessen & Hegeler	V.R.	40,824	1971	
Illinois	New Jersey Zinc	V.R.	58,968	1971	
Montana	Anaconda	E	147,000	1972	
Oklahoma	Amax	H.R.	80,000	1973	Replaced by reopening of electrolytic plant.
Oklahoma	National Zinc	H.R.	55,000	1975	Replaced by new electrolytic plant.
Texas	Asarco	H.R.	48,100	1975	Cannot meet the Texas Air Control Board's standards.
UNITED STATES TOTAL CLOSURES			690,258	'69-'75	
EUROPE					
Holland	Billiton N.V.	H.R.	50,000	1973	Replaced by new electrolytic plant.
Belgium	Metallurgie Hoboken-Overpelt	H.R.	65,000	1974	Replaced by new electrolytic plant.
France	Cia Royal Asturiene	V.R.	96,000	1975	Replaced by new electrolytic plant.
EUROPE: TOTAL CLOSURES			211,000	'73-'75	
Japan	Mitsui	E	22,000	1974	Replaced by expansion at Hikoshima.
TOTAL CLOSURES			923,258		

E – ELECTROLYTIC H.R. – HORIZONTAL RETORT V.R. – VERTICAL RETORT

* Data contained in this Table are current up to March, 1976.

TABLE 4.2.2

NEW ZINC PLANTS AND PLANNED EXPANSION OF ANNUAL CAPACITY
(Electrolytic and Non-Electrolytic)
(Tonnes)

Location	Company	Type of Plant	Remarks	1973	1974	1975	1976	1977	1978	1979	Planned Sub-Total Company Country	Tentative Sub-Total 1973 – 1979	Total Planned 1973 – 1979	Total Tentative 1973 – 1979	Total Planned And Tentative 1973–1979
U.S.A.															
Sauget, Illinois	Amax	E	R.H.	22,680	40,823	12,700	–	–	–	–	76,203	–	–	–	–
Monaca, PA.	St. Joe Minerals	E.T.	Expansion	31,750	20,000	16,300	–	–	–	–	68,050	–	–	–	––
Corpus Christi, Texas	Asarco	E	Expansion	–	–	18,150	–	–	–	–	18,150	–	–	·	–
Stephensport Kentucky	Asarco	E	New/ Tentative	–	–	–	–	–	–	–	–	–	–	–	–
Clarksville, Tennessee	New Jersey Zinc Co.	E	New	–	–	–	–	–	–	81,650	81,650	–	–	–	–
Bartlesville, Oklahoma	National Zinc	E	New (replacement)	–	–	–	50,800	–	–	–	50,800	–	–	–	–
TOTAL U.S.A.				54,430	60,823	47,150	50,800			81,650	294,853		294,853		294,853
CANADA															
Timmins, Ontario	Ecstall, Texasgulf	E	Expansion	–	–	–	–	–	–	–		·	–	–	–
Valleyfield, Quebec	Cdn. Electrolytic Zinc	E	Expansion	–	–	72,575	–	–	–	–	72,575		–	–	–
TOTAL CANADA											72,575		72 575		72,575
MEXICO															
Torreon	Metallurgica Mexicana	E	New	27,215	81,650	–	–	–	–	–	108,865	–	–	–	–
San Luis Potosi	Industrial Minera Mexico (Asarco Mexicana)	E	New	–	–	–	–	99,790	–	–	99,790	–	–	–	–
TOTAL MEXICO											208,655		208,655		208,655

TABLE 4.2.2 cont'd

(Tonnes)

Location	Company	Type of Plant	Remarks	1973	1974	1975	1976	1977	1978	1979	Planned Sub-Total Company Country	Tentative Sub-Total 1973 1979	Total Planned 1973 1979	Total Tentative 1973 – 1979	Total Planned And Tentative 1973–1979
SOUTH AMERICA															
Cajamquilla Lima, Peru	Minero Peru	E	New			–	–	30,000	45,000	–	75,000	–			
Tres Marias Brazil	Mineira de Matais	E	Expansion	–	–	–	27,215	–	–	–	27.215	–		–	.
Altiplano, Bolivia	Machine export U.S.S.R.	E	Feasibility	–	–				30,000	30,000	–	60 000			
Potosi, Bolivia	ENAP	ISF	Tentative	.		–	25,000	–	–	–	–	25 000		–	.
Vinto, Bolivia	Comibol	E	Tentative		–			.	78,000	.	–	78,000			
Votorantim, Brazil	Cia Mineral Metais	E	Expansion	–	–	–	–	26,000	–	–	26.000	–			
TOTAL SOUTH AMERICA											128.215	163,000	128,215	163.000	291.215
EUROPE															
Nordenham, W. Germany	Preussag-Weser-Zinc	E	Expansion	25,000					–	–	25,000	-			
Porto Vesme, Italy	Ammie (state-owned)	ISF	New	30,000	40,000				–	–	70.000	–			
Crotone, Italy	Soc. Mine Met. di Pertusola	E			15,000	15,000	–	–	–	–	30,000				
Overpelt, Belgium	Metallurgie Hoboken	E	New (replacing 70,000)		80,000				–		80.000	–			
Budel, Holland	Zinc de la Campine	E	New (replacing 60,000)		60,000	105,000	–	–	–	–	165 000				
Cartagena, Spain	Espanola del zinc S.A.	E	Expansion			20.000	20.000			-	40,000	–			

TABLE 4.2.2 cont'd

(Tonnes)

Location	Company	Type of Plant	Remarks	1973	1974	1975	1976	1977	1978	1979	Planned Sub-Total Company Country	Tentative Sub-Total 1973 - 1979	Total Planned 1973 1979	Total Tentative 1973 – 1979	Total Planned And Tentative 1973 1979
San Juan, Spain	Austuriana de Zinc S.A.	E	Expansion			35,000					35,000				
Teeside, U.K.	Cominco	E	New Tentative*												
Ireland	Tara, Noranda Northgate	E	New Tentative*												
Macedonia. Yugoslavia	Tito Veles	ISF	New	50,000							50.000				
Sanyii, Turkey	Cinko Kursan Metal	E	New			–	–	–	40,000		40,000				
TOTAL EUROPE											535,000		535,000		535 000
AFRICA															
Algeria	Government	E	New			20,000	20,000				40,000				
South Africa	Zinc Corp. of S.A.	E	Expansion	15,000		–	–	–	25,000		40,000				
Ghazaouet		E	New	40,000							40,000				
TOTAL AFRICA											120,000		120,000		120,000
ASIA & JAPAN															
Debarie, India	Hindustan Zinc	E	Expansion			12,000	–	15,000	–		27,000				
Vizag, India	Hindustan Zinc	E	New			–	15,000	15,000			30,000				
Alwaye, India	Cominco Binani Zinc	E	Expansion Tentative			–	–	–	20,000		20,000				
Rajasthan, India	Hindustan Zinc	ISF or E.T.	New Tentative							100,000		100,000			
TOTAL INDIA											77,000	100,000	77,000	100,000	177,000

TABLE 4.2.2 cont'd

(Tonnes)

Location	Company	Type of Plant	Remarks	1973	1974	1975	1976	1977	1978	1979	Planned Sub-Total Company Country	Tentative Sub-Total 1973 – 1979	Total Planned 1973 – 1979	Total Tentative 1973 – 1979	Total Planned And Tentative 1973 –1979
Miike, Japan	Mitsui Mining & Smelting	V.R.	Expansion	13,600	–	–	–	–	–	–	13,600	–	-	–	–
Hikoshima, Japan	Mitsui Mining & Smelting	E	Expansion	–	23,600	–	–	-	–	–	23,600	–	–	-	–
Namioka, Japan	Mitsui Mining & Smelting	E	Expansion	–	10,300	–	–	–	–	–	10,900	–	–	–	–
Iijima, Japan	Akita Smelting	E	Expansion	–	–	–	78,000	–	–	–	78,000	–	–	–	–
TOTAL JAPAN											126,100		126,100		126,100
Amphoe, Thailand	Thailand Zinc	E	New	.				-							
Onzan S. Korea		E	New	–	–	–	–	–	50,000	–	50,000	–	50,000		50 000
AUSTRALIA															
Risdon, Tasmania	Electrolytic Zinc of A	E	Expansion	–	20,000	–	–	–	–	.	20,000	–	20,000		20,000
TOTAL FREE WORLD				255,245	391,973	326,725	236.015	185,790	288,000	211,650	1,632,398	263,000	1,632,398	263,000	1,895,398

E – Electrolytic Plant
V.R. – Vertical Retort
E.T. – Electrothermic Plant
R.H. – Rehabilitated
I.S.F. – Imperial Smelting Furnace
ENAF – Empresa Nacional de Foundiciones
COMIBOL – Corporation Minera de Bolivia
* – Feasibility Stage Plans not finalized

TABLE 4.2.3

CAPITAL COSTS FOR ZINC REFINERY COMPLEX

YEAR OF COMPLETION	COMPANY	LOCATION	ANNUAL CAPACITY (tonnes of zinc)	PROJECT CAPITAL COST ($ Million)	CAPITAL COST PER ANNUAL TONNE OF CAPACITY ($/t)	NEW OR EXPANSION	REMARKS
(1) 1963	Canadian Electrolytic Zinc Ltd.	Valleyfield Quebec	76,205	$ 16	$ 210/t	NEW	Roasting facilities not included, as Allied Chemicals and Alcan supplied calcine feed. No infrastructure was required.
(2) 1972	Akita Zinc Company Ltd.	Iijima Japan	78,000	39	500	NEW	Exclusive of cost of 6 years' development and engineering.
(3) 1972	Texasgulf Canada Ltd.	Timmins Ontario	108,864	80	735	NEW	Batch leaching and purification.
(4) 1973	Industries Penoles	Torreon Mexico	105,000	72	685	NEW	
(5) 1976?	Canadian Electrolytic Zinc Ltd.	Valleyfield Quebec	72,576	61	840	Expansion	
(6) 1975	Hindustan Zinc Ltd.	Visakhpatam India	30,000	29*	967*	NEW	
(7) 1976	Industrial Minera Mexico	San Luis Potosi Mexico	99,790	96*	962*	Expansion	
(8) ?	Asarco	Stephensport Kentucky U.S.A.	163,300	160*	980*	NEW	As of July 1975, this project has been postponed.
(9) 1979	New Jersey Zinc	Clarkesville Tennessee U.S.A.	81,650	112	1,372*	NEW	Union Miniere, Belgian based Company will have a 40% interest in this project.
(10) ?	Cominco	United Kingdom	100,000	110	1,100*	NEW	Exclusive of government construction grants: Postponed due to unfavourable economic and market conditions.

* ENGINEERING COST ESTIMATES.

TABLE 4.2.4

**ESTIMATES OF PRODUCTION COSTS
FOR
AN ELECTROLYTIC ZINC PLANT
(110,000 TONNES PER YEAR)**

LABOUR AND SUPERVISION COST

	SUPERVISORY	LABOUR	RATE $/YR	TOTAL 000$/YR	TOTAL $/t
Concentrate Handling Roasting, Sulf. Acid	6	35			
Leach-Purification and Residue Handling	9	50			
Water Reclamation	1	8			
Zinc Cellroom	5	42			
Melting-Casting-Dross Handling-Zinc Dust	6	40			
Maintenance and Shops	15	120			
Plant Services	27	25			
Administration	5	0			
SUB TOTALS	74		$20,000	$1,480	$13.45
		320	$14,000	$4,480	$40.73
TOTAL, LABOUR AND SUPERVISION				$5,960	$54.18

TABLE 4.2.5

ESTIMATES OF PRODUCTION COSTS FOR AN ELECTROLYTIC ZINC PLANT (110,000 TONNES PER YEAR)

	TOTAL 000 $/YR	TOTAL $/t
TOTAL, LABOUR AND SUPERVISION	$ 5,960	$ 54.18
Power 4,960 kw/t Zinc @ 9 MIL/kw	4,911	44.60
Steam 1.9 t/t Zinc @ $3.16/t of steam	662	6.02
Operating Materials and Reagents	1,091	9.92
Spare Parts and Maintenance Materials	4,243	38.58
TOTAL PRODUCTION COST	$16,867	$153.30/t

TABLE 4.2.6

**ESTIMATES OF TOTAL COSTS
FOR
AN ELECTROLYTIC ZINC PLANT
(110,000 TONNES PER YEAR)**

	TOTAL COSTS	
	000 \$/YR	\$/t Zinc
TOTAL PRODUCTION COST (see Table 4.2.5)	\$16,867	\$153.30
AVERAGE INTEREST COST *	3,700	33.33
DEPRECIATION (Straight-line over 15 years)	7,300	66.67
TOTAL COSTS (11.5¢/lb.)	\$27,867	\$253.30/t

* (\$1,000/t capital cost with 5-year pay back and 10% interest, amortized over 15 year period).

Chapter 5 Scrap Zinc

In this section the movement and disposition of scrap (secondary) zinc is traced from the point where the metal enters the market in the form of end-use products (such as die-casting rolled products, galvanized steel, brass alloys, etc.) to the point of return as secondary or scrap metal. Two problems are faced in accounting for scrap consumption in the published data:

1) zinc consumption statistics include slab zinc, old and new scrap, ore and oxides;

2) new scrap generated from slab zinc consumption is included in the statistics as a source of supply.

Therefore, net zinc consumption in a market could properly be defined as gross inputs of zinc, less the recoverable new scrap, old scrap and direct ores.

Zinc essentially is categorized as:

i) primary slab zinc
ii) redistilled secondary slab zinc
iii) oxide, sulphate and chloride
iv) secondary or scrap zinc consumed for dust, and oxide manufacture from
   a) old scrap
   b) new scrap.

Secondary zinc from old scrap is generally substitutable for primary slab zinc from a demand point of view, but its supply characteristics are somewhat different. Old scrap accounts for a very small share of total zinc consumption, only 4.8% of the total U.S. zinc consumption of 1.75 million tonnes in 1973.

New scrap is relatively more important. To cite an example, in the U.S. it equalled about 15% of the U.S. domestic zinc consumption in 1973. This proportion has remained in the range of 14% to 18% since 1966. Since new scrap is generated by industrial consumers, in the process of making galvanized steel, die-casting, etc. from slab zinc, it is therefore deemed desirable to treat new scrap in the analysis by subtracting it from consumption rather than presenting it as a separate source of supply.

Thus, there seems to be no large distortion if analysis is concentrated on slab zinc production and consumption. This is explained in Table 5.1.1 by presenting the 1972 and 1973 scrap flows in the United States. The imbalance of 80 924 tonnes between estimated and reported consumption in 1973 represents only 6% of the total reported consumption of slab zinc in the U.S.

Slab zinc accounts for about 70%–80% of total production, with the remainder accounted for by oxides, sulphates, chloride, scrap consumed for dust and oxide manufacture and other minor uses. All zinc products, such as brass, die-castings, rolled zinc and light base metal alloys are the present sources of zinc scrap. Zinc consumed in galvanizing and as dust, oxide, sulphate and chloride cannot be recovered economically.

Zinc products are potentially recoverable once they enter the market and upon completion of their life cycle. The factors affecting recovery are recovery technology, costs and metal prices.

The life cycle of a product is the time during which some use for that product exists. This time period can usually be divided into a primary useful period and a secondary useful period. It is assumed that a product is not available for recovery until its life cycle is complete.

The use of life cycles and recovery percentages can be clarified with an example. Zinc die-castings used in automobiles were assigned an average life cycle of 10 years in the United States. This was determined by considering both the primary useful life of an automobile for transportation and its secondary useful life for parts. This means that the average automobile becomes available for recovery 10 years after it is first produced. At the present time only 20 percent of the zinc in die-castings consumed by the automotive industry, and available for recovery is actually recovered. The remaining 80 percent has a future availability as technology for scrap collection and concentration improves and scrap prices increase.

TABLE 5.1.1

THE U.S. SCRAP FLOW AND CONSUMPTION IN 1972 AND 1973

	1972	1973
	Tonnes	
Total U.S. Zinc Consumption	1,659,045	1.752,642
Less: (1) new scrap	279,766	266,900
	1,379,279	1,485,742
(2) old scrap	72,011	84,675
	1,307,268	1,401,067
(3) Ores	107,326	117,619
Net Slab Zinc Consumption	1,199,942	1,283,448
Actual reported slab zinc consumption	1,286,726	1,364,372
Difference between Actual & Net Consumption	86,784	80,924

Chapter 6 Impact of Technology

Increasing demand for zinc, more stringent specifications and the ever-present pressure to control and reduce production costs have led zinc producers to develop processes to produce high-purity zinc at improved recoveries, lower labour costs and without polluting the environment.

The milling and concentrating stages recover about 92% of mined zinc as concentrate in the form of zinc sulphides. Zinc concentrates contain normally 50%–65% zinc as well as other metallic impurities such as copper, lead, iron, cadmium, silver, gold, etc. The concentrate is roasted to remove sulphur and to convert the sulphides to oxides. The product at the end of the roasting stage is known as calcine and is acid-leached in several steps to extract zinc. The leach residues are treated to recover contained lead and silver. The leach liquor, containing zinc, cadmium, iron, copper, etc., is treated to remove all impurities that will interfere with electro-winning of pure zinc. Iron is removed by precipitation in the Jarosite and Goethite processes; cadmium and copper are removed by cementation with zinc dust, which also separates such impurities as arsenic, antimony, nickel, cobalt, tin, etc. These impurities may be recovered separately. Zinc is extracted from the purified solution by the electrolytic process and the electrolyte is recycled to the first stage of leaching. The cathodes are melted and cast into slab zinc of the required specification.

Technological development in the zinc industry has been intensive in both the primary metal extracting stage and the secondary semi-fabricating end-use sector. Research and development work in the past decade has successfully developed processes for the extraction of zinc from ferritic calcines which had previously been discarded. This advance has increased the zinc recovery from concentrates from 88-90% to about 96%. Currently, developments in automation of the tank-house have reduced costs in this traditionally labour-intensive segment of the primary zinc industry. Advances in die-casting techniques – particularly thin-wall casting – and in galvanizing practice have led to lower costs and wider application in these zinc consuming sectors of the industry, which are discussed in detail in Section 7.

6.1 Roasting

While developments in the zinc extraction and reduction processes were taking place, parallel advances in zinc roasting technology were also occurring. Roasting, to remove the sulphur from sulphide ores in preparation for thermal reduction or leaching for electrowinning, was principally done in multiple hearth roasters, or Dwight-Lloyd sinter machines or both.

The first alternative to these processes was the flash roaster developed by Cominco and adopted on a world-wide basis in the 1930's. Pellet roasting, in vertical columns and in horizontal beds was also developed. Fluid bed roasting – which avoids the need of pelletizing and subsequent grinding – was developed by the Dorr Company (now Dorr-Oliver Inc.) and by the Vieille Montagne Company in Belgium. The two types of roasters each have their own advantages; the Dorr zinc roaster design uses slurry feed whereas the Vieille Montagne type takes dewatered feed.

The factors which have encouraged the development of these processes have been the need for: greater sulphur removal, more control over sulphate formation, improved lead removal, high SO_2 content in the roaster gas for sulphuric acid production and greater unit throughput for reduced cost.

Fluid bed roasting produces a calcine of improved solubility in the electrolytic process. The fluid bed roaster also produces a calcine with lower sulphide sulphur but higher sulphate sulphur. This could reduce acid consumption in a plant using the Jarosite process, where sulphate is lost in the Jarosite precipitate.

6.2 The Electrolytic Process

The horizontal retort process was the principal method of producing zinc up until the time that the electrolytic process became commercial. The electrolytic process was developed by Cominco and brought into commercial production in 1915.

From the beginning the process was developed in a number of alternatives, some of these being:

- continuous versus batch treatment in leaching, residue filtration and purification;
- level of current density in the electrolytic cells;
- electrolytic cooling system (individual cells versus whole electrolyte stream).

Recently commissioned zinc plants, almost without exception, have adopted the electrolytic process. This process possesses several compelling advantages, one of which is its ability to produce economically all of the grades of zinc that are in demand, from Special-High-Grade to Prime Western. Equally important is the availability of leaching techniques which extract the zinc formerly lost in the zinc ferrite residues, i.e. the Jarosite Process and the Goethite Process. One or the other of these processes has been adopted in most previously existing electrolytic zinc plants.

Leach Residue Treatment: In both the Jarosite and the Goethite processes, the zinc ferrite is leached by a strong sulphuric acid solution. In the Jarosite Process, the ferric iron is precipitated from solution as sodium, potassium or ammonium jarosite. In the Goethite Process ferric iron is precipitated from solution as goethite, a hydrated ferric oxide. The important feature of both processes is that under the appropriate conditions of pH and temperature, the precipitated iron, whether jarosite or goethite is in a filterable form that can be readily separated from the solution.

Application of these processes to individual plants shows a high degree of flexibility, and a variety of developments

are occurring which will enhance the economics of the processes.

In a paper presented in 1974*, the emerging technical improvements which are being installed in the current generation of zinc plants, were listed as follows:

- preleaching of concentrates for magnesium removal;
- fluid bed roasting;
- double catalysis acid plant;
- continuous neutral leaching or calcine;
- hot acid leaching of ferritic zinc;
- iron precipitation as jarosite or goethite;
- continuous hot-cold purification of leach solution with $CuSO_4$, As_2SO_4, and zinc dust, or the alternative method using antimony in place of copper and arsenic sulphates;
- automated filter presses;
- automated solution analysers;
- automatically controlled cooling towers or evaporators for purified solution and circulating electrolyte;
- automated cathode handling and stripping;
- automated casting and stacking;
- liquid effluent treatment and water reclamation.

These innovations are directed at reducing labour costs, improving recoveries, reducing pollution and increasing the purity of the product.

AUTOMATION OF CATHODE HANDLING AND STRIPPING:

At present the problems of automation in the cell room are receiving a great deal of attention. Two companies have automated their cell rooms and licensed the systems commercially, the Akita Zinc Company in Japan, and Societe des Mines et Fonderies de Zinc de la Vieille-Montagne in Belgium.

Automation in the cell rooms has increased the productivity of the stripping operation, for example from 7 tonnes to 16 tonnes per man-shift at the Balen plant of Vieille-Montagne. Automation has been applied to the following operations in the stripping procedures:

- removal of cathodes from the cells and transportation to the stripping station;
- stripping and removal of the deposited zinc;
- conditioning of the stripped cathode, and its transportation to, and placement in the cells.

6.3 The Horizontal Retort Process

Zinc was first produced in commercial quantity by the horizontal retort process, introduced in 1800. It was a batch distillation process, using small, externally heated retorts, with individual condensers. This process was used, with improvements and variations, up until a few years ago. Its disadvantages were severe by today's standards; fuel costs were high because of poor thermal efficiency and expensive metallurgical coke was required as the reductant. The process was labour intensive, and the nature of the process provided very hot, uncomfortable working conditions. Metal recovery was inefficient and resulted in a heavy recycle load to maintain overall recovery at an acceptable level.

6.4 The Vertical Retort Process

The vertical retort process was introduced by the New Jersey Zinc Company in the 1930's. The process involved charging a strong coked briquette containing zinc calcine, into a vertical shaft furnace. The furnace was operated continuously, and many of the difficulties associated with the horizontal retort process were avoided. The vertical retort process provided mechanized charging of the retort, better fuel efficiency, higher zinc recovery and higher furnace efficiency than the horizontal retort. The use of a "splash condenser" reduced the amount of zinc oxide "blue powder" produced from about 12% to the 3%-5% range. The zinc recovery based on furnace input was 95% and overall zinc recovery was about 92%. The retorts operated with a thermal efficiency of about 45%. The vertical retort furnace produces Prime Western Grade zinc; Special High Grade is produced by distillation.

In spite of these improvements over the horizontal retort process, escalating costs of coke, natural gas and labour, as well as severe environmental problems have reduced the profitability of these plants. The last vertical retort plant in the U.S. was shut down in 1971.

6.5 The Electrothermal Process

The electrothermal process was developed by the St. Joe Mineral Corporation in the 1930's, and zinc metal production started in 1936. The thermal energy required for the smelting of zinc is developed by passing an electric current through a bed of coke and zinc sinter. Resistance heating develops the energy internally in the furnace and overcomes the thermal inefficiencies inherent in external retorts; a thermal efficiency of 80% has been reported for the "large" furnaces. These furnaces are 2.4 meters inside diameter by 15 meters high, and have a production capacity of 100 tonnes of zinc per day.

The grade of zinc produced by the electrothermal process is controlled by careful selection of the feed materials. "High Grade", "Intermediate" and Prime Western grades of zinc are produced. Special High Grade zinc is produced by distillation. The process is uniquely suited to processing a wide variety of zinc bearing materials, including secondary

*G.M. Meisel, "New Generation Zinc Plants, Design Features and Effects on Costs". J. Metal Vol. 26, p. 25, August, 1974.

materials with metallic as well as oxidic zinc. The ability to treat internally generated residues has resulted in an overall zinc recovery of 95%. The process is presently being used in the United States and Japan, and appears to be economically viable to date.

6.6 Zinc Plant Residue Treatment Process

Virtually all zinc smelting processes produce quantities of zinc-rich residues which cannot be internally recycled. A number of processes have been developed to extract this zinc economically. Residues consist of a complex variety of materials; retort residues and blast furnace slags contain up to 15% and 19% zinc, respectively, and leach residues from electrolytic plants contained up to 28% zinc. Most recovery processes exploit the volatility of zinc, lead and cadmium at high temperatures, and involve reduction with coal or coke and subsequent collection of the zinc oxide fume produced. Processes such as the Waelz process, the slag fuming processes and the Zileret process have followed this technique. The most recently developed processes are the Jarosite and the Goethite processes for the treatment of ferritic zinc leach residues. These rely on strong acid leaching followed by iron precipitation.

6.7 The Imperial Smelting Process

This process was developed by the Imperial Smelting Corporation at Avonmouth, England in the 1950's and the first Imperial Smelting Furnace (ISF) was brought into commercial production in 1959. At present (1976) 11 plants are in operation throughout the world, producing 11% of the world's total zinc output. Additional ISF capacity is scheduled to come on-stream in Poland in 1977.

The Imperial Smelting Process was developed to treat complex lead-zinc ores for the simultaneous recovery of metallic lead and zinc, as well as efficient recovery of precious metals, and minor elements in the ore such as copper, bismuth and cadmium. In contrast to retort smelting and the electrolytic process, the iron content of the charge has only a small effect on the metal recoveries. In furnaces using a high-grade charge (e.g. 60%-65% of zinc plus lead) recoveries of up to 93% have been achieved. Improvements in slag chemistry have resulted in a marked reduction in the amount of zinc lost in the slag. However, the process requires metallurgical coke and is sensitive to its constantly increasing price. The ISF process can treat only a carefully balanced lead-zinc feed and does not offer flexibility. It requires regular shutdown and maintenance, thus lowering the annual operating capacity.

In the Imperial Smelting Process, fluxed lead-zinc concentrates are sinter-roasted, and then reduced with coke in a blast furnace of special design. The zinc metal is volatilized and subsequently condensed in a spray of molten lead. The lead in the charge is recovered as bullion from the bottom of the blast furnace. Zinc is separated from the condensing lead by cooling; the zinc is quite impure and must be further refined to produce marketable grades.

The lead bullion contains all silver and gold values from the concentrates, as well as the usual impurities typical of blast furnace lead bullion. Refining of the lead is required to up-grade its quality and to recover the precious metals. Any copper present in the ore reports with the lead. Techniques are presently being developed to recover the copper in a marketable form, either as cathode copper or copper sulphate.

The zinc produced contains about 1.2% lead, which is too high for present day applications. A technique has been developed to produce a "vacuum dezincing" (VDZ) grade of zinc metal containing 0.3% lead and 0.003% iron; the cadmium content at this stage depends on the feed; cadmium-free zinc would require further refining. The quality of VDZ grade zinc is different from established grades, and it would take some time to establish a market for this material.

In standard plant operations, the zinc metal from the ISF condenser and separation circuit is refined in a distillation plant based on the New Jersey refluxing process. The product is Prime Western grade, and Special High Grade zinc, in proportion as required by the market.

Currently, ISF research efforts are being directed towards extending the range of materials that can be smelted, improving the fuel economy of the furnace, by improving the charge distribution and using alternative fuels, upgrading the performance of the furnace shaft and the splash condenser and improving the quality of the products.

6.8 New Processes

Research is being directed toward such problems in the zinc industry as:

- sulphuric acid generation;
- improved overall extraction efficiency;
- improved purification techniques;
- pollution problems.

The conventional processing of zinc sulphide concentrates involves roasting with the accompanying production of sulphuric acid. Processes which yield elemental sulphur rather than acid would provide the advantage of long-term storage of sulphur, cheaper transportation and a wider market.

Although the introduction of processes to recover zinc from zinc ferritic residues has significantly increased recoveries, the residues from the Jarosite and Goethite processes still contain enough zinc to be of interest. Processes now under development, such as acid washing of jarosite, hydrothermal conversion of the iron precipitate and thermal decomposition of iron precipitates are aimed at improved extraction of zinc, and production of iron residues in a form suitable for iron making. Should these goals be realized, a significant waste disposal problem would be alleviated.

Sherritt Gordon Mines Limited has developed a high-pressure acid-oxygen leach process for the extraction of zinc and sulphur from zinc sulphide concentrates. The process yields zinc in sulphate solution and sulphur in elemental form. Initial work yielded zinc extraction from concentrate of up to 98% and an elemental sulphur yield of up to 89%. The presence of iron in the feed was found to enhance the zinc extraction rate. However, retention times of up to 8 hours were required to achieve these levels of extraction. Subsequent developments reduced the retention time to about 2 hours by increasing the reaction

temperature to about 149°C, the oxygen partial pressure to about 30 psi and maintaining a stoichiometric excess of zinc sulphide concentrate over the amount of acid present.

The zinc solution produced can be purified by conventional means. The recoveries of zinc and elemental sulphur were in the range 96%-98% and 80%-85% respectively. This process has the important advantage of recovering sulphur in the elemental form, and accepting zinc sulphide concentrates as feed rather than calcine. Other advantages cited for the process include potentially lower capital and operating costs, flexibility in feed materials and ease of process control.

Research at the Berzelius smelter of Metallgesellschaft in West Germany has resulted in a process for treating low-grade secondary material such as steel plant dust, containing as little as 3% zinc. The feed is treated in a Waelz kiln to separate zinc and lead from the iron oxide. The iron oxide is suitable for iron-making and the zinc and lead concentrate are then agglomerated by the hot-briquetting process and can be fed to the ISF.

Some zinc concentrates contain environmentally significant quantities of mercury. During the roasting step of processing, the mercury is volatilized, and is either removed from the roaster gases by the gas scrubbing equipment, or reports in the sulphuric acid produced from the SO_2 in the roaster gases. A mercury-recovery technique has been developed recently by Outokumpu Oy in Finland, in which the mercury is precipitated from the acid, and the precipitate treated to recover pure metallic mercury. In facilities lacking mercury recovery processes, the mercury content in the roaster gases can only be controlled by limiting the total mercury content of concentrates supplied to the plant.

Chapter 7 Substitution

The impact of substitution for zinc is discussed in three major consuming sectors of galvanizing, die-casting and brass.

7.1 Galvanizing

Zinc galvanizing is applied to protect steel against corrosion in uses such as motor vehicles, construction, fencing and hardware. Zinc coating provides the least expensive and best protection against rust and corrosion for countless steel products. Zinc is a most versatile material for this purpose since it can be applied in five different ways:

1) by hot dip galvanizing;

2) by electrodeposition or electrogalvanizing;

3) by metallizing or spraying of molten metal;

4) by sherardizing or cementation; and

5) by painting.

Each of these methods has its particular advantages, and in certain applications is to be preferred.

Potential substitutions for galvanizing may be viewed as twofold:

1) substitution of zinc galvanizing with other means of protecting the steel; and

2) substitution of corrosion-protected steel with other materials.

Alternative methods of rust-proofing are aluminum coatings, plastic coatings, paints and rust-resistant steel. Although aluminum coating is available, a wide-spread application is feasible only if present technical difficulties are overcome. Paints and other coatings are cheaper in material cost but generally are more labour-intensive and do not offer savings.

In order to determine the benefit of galvanizing, it is necessary to compare the cost of alternative protection, or barriers, such as zinc-based paints, spread over the estimated useful life of the steel structure. This involves the "time value of money".

7.1.1 GROWTH OF GALVANIZING

Galvanizing could be the fastest growing sector of the zinc industry in the foreseeable future. A recent Australian study indicated that galvanizing maintained structural steel in good condition for 10 years, compared to paint protection which lasted only 4 years. A combination of galvanizing and top-coating extended the structure's life to 16 years. Australian climatic conditions are considered a hostile environment, quite conducive to corrosion.

The cost of zinc represents about 15%-26% of the current price for galvanized steel, depending on the thickness of coating and the product being coated. Zinc used on galvanized steel could be up to a maximum of 91 kilograms (200 pounds) per tonne of steel. Thus, a 2.2 cents per kilogram (one-cent-a-pound) increase in zinc price could result in a $2 per tonne increase in galvanzied steel procurement cost.

Competition between galvanized steel and materials other than steel is likely to be much more heavily influenced by the price of steel than by the price of zinc. However, as the zinc price rises, a thinner zinc coating may be applied or one-sided galvanized sheets made available. The amount of protection against corrosion depends largely upon the weight of zinc coating – the heavier the coating the longer the rust-free life of the base metal – as indicated in Table 7.1.1. Galvanizers are adopting energy conservation measures in order to reduce sharply rising costs for both natural gas and petroleum-based fuels. The application of computers to the galvanizing process reduced zinc consumption by at least 5% and greatly improved quality control.

7.1.2 GALVANIZING IN THE AUTOMOBILE SECTOR

Applications for zinc-coated steel in automobiles and trucks are going up. Awareness of corrosion problems associated with the increased use of salt and other snow-melting chemicals has increased the demand for the use of galvanized steel in car bodies. More exposed components such as fenders, doors, quarter panels, tailgates and light bezels are being designed to employ zinc-rich coatings of one type or another. Better drainage conditions also are being built into the cars and non-zinc coatings and liners such as plastics, waxes and special enamels are being specified more and more in areas where zinc coatings are not applicable or too costly. The amount of galvanized steel in 1976 cars will total about 68 kilograms per car, up from 45 kilograms in 1973. By the year 1980, the use of galvanized steel in cars could increase to about 91 kilograms per car. This would increase the annual demand to 7 million tonnes by 1980 from 6 million tonnes of galvanized steel in 1976.

7.1.3 GALVANIZING IN THE AGRICULTURAL SECTOR

The outlook for the agricultural sector in both equipment and farm buildings appears quite promising, offering potential growth for galvanized steel. The U.S. domestic shipments of galvanized steel to the agricultural sector have grown to 6% of total shipments in 1974. This is up from 4%, 10 years ago. In quantity, galvanized steel shipments to the agricultural industry has increased by 150% between 1964 and 1974.

7.1.4 GALVANIZING IN THE TRANSPORTATION SECTOR

Neither highway nor bridge projects were important markets for galvanizers in the past. Highway departments in the United States and two Canadian provinces are turning to

galvanized reinforcing steel as a means of saving the costs of bridge deck deterioration. In 1976, Pennsylvania will use about 10 400 tonnes of galvanized re-bar, more than its total for the past 3 years. Indiana is scheduled to install 9 bridge decks using galvanized re-bar; New York 8; Iowa and New Jersey, 5 each. Other states which are considering increased use of galvanized steel include Florida (where one project alone could require 6000 tonnes of galvanized re-bar), Michigan, Illinois, Minnesota, Idaho, Ohio and Colorado.

7.1.5 GALVANIZING IN THE PETROCHEMICAL SECTOR

With each new generation of petrochemical plant, the application of galvanized steel has increased as companies continue to seek means of prolonging the life of steel used in these facilities. With continued expansion, the petrochemical industry will remain a growing customer for galvanizers.

TABLE 7.1.1

*ESTIMATED LIFE OF ZINC-COATED PRODUCTS IN THE ATMOSPHERE

Thickness, in.**	Weight in oz./sq.ft. of Surface**	Life in Years under Atmospheric Conditions					
		Rural	Tropical Marine	Temperate Marine	Suburban	Urban	Highly Industrial
.0036	2.00	50	40	35	30	25	15
.0023	1.25	35	30	25	20	17	9
.0018	1.00	25	20	15	12	10	7
.0011	0.60	10	8	7	5	4	3
.00066	0.37	7	6	5	4	3	2
.00044	0.25	5	4	3	3	2	1

* From "Protective Coatings for Metals", American Chemical Society Monograph Series No. 129, Burns and Bradley. Courtesy: Reinhold Publishing Corporation, New York, N.Y.

** In case of galvanized steel sheets the weight of zinc is specified in terms of total zinc on both sides of the sheet; i.e. a 2 oz. sheet has 1-oz. of zinc per sq. ft. of surface. Consequently the weight of zinc and its thickness as stated must be halved in the table above when sheet of specific coating weight is considered.

SOURCE: A Mine to Market Outline Zinc; Zinc Institute.

7.2 Die Casting

Die-casting is the process of producing dimensionally accurate parts by forcing molten metal under pressure into a polished steel die or mold. The transition from a molten metal to die-cast part may be accomplished in the period of a fraction of a second to a fraction of a minute with each cycle of the die-casting machine. Because of the complexity of shapes possible and the excellent properties of the parts made by die-casting, the process is among the most important high volume production methods in the metal working industry. The use of the die-casting process has been growing steadily for well over forty years and its future is very promising.

The die-casting process requires the highest level of manufacturing skills. The die-casting industry is devoting a major effort to automated techniques in order to save energy and labour costs. An example is the awareness and effort to conserve energy in melting and holding molten metal in the production of die-castings. Melting ranges of die-casting alloys are: 381-387 deg. C for zinc; 538-593 deg. C for aluminum and 468-596 deg. C for magnesium. The low melting point of zinc means savings in energy costs, quicker cooling of castings, and this makes it possible to produce die-castings at a speed which cannot be attained with other metals commonly used. Dies last longer since they operate at lower temperatures. Because of the high fluidity and flexibility of zinc alloys at casting temperature, single die-castings of highly complex design can be made to combine several parts, thus making it possible to eliminate alternative and expensive assembly operations.

Complete automation of the entire die-casting process is not nearly as far off as it appeared to be a few short years ago. The recent development which promises to significantly affect the die-casting industry has been the introduction of a number of die-casting machines which not only cast, but also quench, trim and in some cases perform secondary machining operations automatically. The increased interest in new automated zinc die-casting machines suggests that the future of zinc lies in automation for high volume parts. In addition, automation would result in lowering the labour cost per part and increasing the competitiveness of zinc on the substitution front.

7.2.1 ZINC DIE-CASTING AND ITS MAJOR SUBSTITUTES

Zinc has for many years been the most widely used metal for die-castings. Zinc base alloys are the most adaptable to the process. The development of the modern zinc die-casting alloys has been based on (a) the use of Special High Grade Zinc (99.99+% pure), (b) the addition of particular alloying constituents which are held within close limits, and (c) the control of impurities. It is essential to use 99.99+% pure zinc to assure an extremely low iron, lead, cadmium and tin content. (See Appendix C).

Aluminum, magnesium and plastics are serious competitors in the die-casting industry. The volume of aluminum and magnesium in die-casting markets has been expanding more rapidly than that of zinc. However, much of the growth in aluminum usage has been in non-competitive areas such as in products requiring higher temperature resistance than zinc can tolerate. Thus, the expansion of aluminum in die-casting may be complementary to zinc even though the two metals are active substitutes within the market.

Zinc's competitors, aluminum and plastics, are also facing escalating prices. As the price of all raw materials continues to escalate, the need to use less in each part becomes apparent.

Cost reductions are a major consideration in the automotive, appliance and other mass production industries. As a result, traditional high-volume production methods such as zinc die-castings, when combined with the latest technology can produce thin-wall, light weight castings which not only help insure high-quality products but also can win price points in the highly competitive market place. This is accomplished through material savings, reduced scrap, increased production rates and reduced labour and energy costs. In many instances, the application of thin-wall zinc die-casting is indispensible if zinc die-castings are to remain competitive with other materials such as aluminum and plastics. Using thinner than standard wall thicknesses significantly decreases costs and such cost savings are especially important in large volume applications such as the automobile industry.

7.2.2 IMPACT OF ENERGY ON ZINC AND ITS SUBSTITUTES

The rising cost of energy is causing shifts in the relative competitive position of: zinc, aluminum, plastics, steel and copper. The total energy requirement to convert major metals from ore in the ground to the refined (ingot) stage per tonne* of metal is compared with that of plastics in Table 7.2.1. The energy requirements for producing zinc are 3 kWh per pound compared to 10-12.5 kWh per pound for aluminum and 12.5 kWh per pound for plastics. Table 7.2.1 demonstrates the versatility of zinc in terms of energy costs, as the energy required for aluminum and plastics is about 3.3 to 4 times that of zinc. Plastics would rank just below aluminum, with about the same fuel requirement as aluminum, but at half the cost.

Analyzing the energy profile of metals, Agarwal and Sinek** presented the approximate fuel requirements to mine, process and refine several base metals as summarized in Table 7.2.2. Assuming fuel has an average delivered cost of \$1.00 per million BTU and coke \$2.00, Table 7.2.2 indicates the percentage of fuel costs as represented in the sale price of the metal. Total fuel costs, as a percentage of current prices are 7.3% for zinc and 34.2% for aluminum. Thus zinc is considerably less sensitive to this factor than aluminum.

If the price of energy increased by 10 mills per kWh, the price of zinc would rise by 6.6¢ per kilogram and aluminum by 24¢ per kilogram. The energy required in the secondary

*M.R. Davidson, "Zinc, A Versatile Strategic World Commodity", Automotive Engineering Congress and Exposition, Feb., 1975.

**J.C. Agarwal, J.R. Sinek, "The Energystics of Metal Production", Energy Use and Conservation in the Metals Industry, Proceedings of a symposium at the 104th AIME Annual Meeting, Feb. 1975.

or fabricating sector is another factor to be considered in evaluating the true competitive position at the consumer level.

7.2.3 ZINC VERSUS PLASTICS

It is generally recognized that zinc die-casting and plastic injection molding are among the most economic processes for producing complex shapes.

Zinc and plastics find their widest applications in the automotive, appliance and plumbing industries. The material selection is based principally on weight and cost considerations, however, auto-body stylists and material engineers point out that plastics are improving in quality. Since the raw material for plastics is petroleum, injection molders are faced with a diminishing cost differential between their products and zinc die-castings. The weight benefits of plastics are becoming less significant than the cost benefits, as a result of the development of thin-wall zinc die-castings.

The use of plastics in automobiles has been expanding since the early 1960's. Injection molding of plastics can achieve the same dimensional accuracy as zinc die-casting for any shape. Thermoplastics offer a serious threat to zinc: ABS (Acrylonitrile Butadiene Styrene) is the principal thermoplastic competitor for zinc die-castings, but other thermoplastic substitutes such as acetal, nylon (injections), and polycarbonate, are a growing force. ABS, unlike other plastics, can be electroplated, improving the material's strength. The major advantage of electroplated plastic is the lower cost of the material. However, zinc retains certain advantages over plastics, such as superior heat resistance; zinc die-castings are also much better structurally and functionally.

In the U.S., the Ford Motor Company recently announced its plans to conduct a study on the benefits of switching from zinc to plastic for the heads and bases of the outside rear view mirror assemblies on all its cars. Fisher Body division of General Motors has decided to switch from conventional zinc die-casting mirror heads and bases to thin-wall units later in 1976, as they decided that plastic units would not be as cost effective as zinc parts.

To determine the relative merits of zinc and plastics, the following major points must be considered:

a) costs of tooling and production;

b) process capability relating to dimensional repeatability;

c) material properties throughout products; and

d) temperature range.

Plastic tooling costs can be 2 to 4 times greater than die-cast zinc tooling cost in the case of large scale production. Comparison of production methods for both plastic and zinc must be studied in detail to determine which material has the lowest cost. The electroplating of plastics is much more costly than zinc (and other conductors), and the adhesion and field service life are definitely inferior. In many cases, where thin-wall zinc die-castings can be plated directly from the trim operation, the final production cost will be less than that of plastics because of labour savings.

The operating cost for plastic molding is 2.5 times that of a zinc die-casting. Evaluation of cycle times indicates that a zinc molding is typically completed each 12 to 15 seconds, whereas a similar plastic molding is completed in 40 to 90 seconds, depending on boss and rib shape. Typical operating costs of a zinc die-casting machine and trim press are \$40 per hour compared with that of an injection molding machine at \$25 per hour. A die-casting machine running at 300 parts per hour will result in a cost of 13.3¢ per part, whereas a plastic molding machine running at 75 parts per hour would cost 33.3¢ per part, 2.5 times the cost of the zinc part.

7.2.4 ZINC VERSUS ALUMINUM

The use of aluminum in automobiles has grown significantly in recent years because of its role as a light-weight material. The average 1975 model U.S. passenger car contains 23 to 27 kilograms of aluminum castings. It is estimated that there may be 32 kilograms per car by 1980, and as much as 45 kilograms per car by 1985. However, very little growth is estimated in the use of zinc die-castings in U.S. automobiles, which now contain 20 to 23 kilograms per car.

Although aluminum usage is increasing due to the auto industry's efforts to reduce vehicle weight, thin-wall die-casting techniques have helped to keep zinc competitive.

Direct competition between aluminum and zinc die-casting is only marginal, particularly as aluminum cannot readily be plated. Currently the emphasis is on zinc products, despite predictions that aluminum and plastics would replace zinc in the drive for lighter weight parts. However, in three or four applications, zinc and aluminum die-castings have in fact replaced plastics. The move now appears to be to both aluminum and zinc with no indication that aluminum or plastics are replacing zinc.

7.2.5 ZINC VERSUS MAGNESIUM

The use of magnesium die-castings in the automobile industry results from the metal's relatively light weight. At this time, magnesium is used very sparingly by the automobile industry. Magnesium's biggest disadvantage in the U.S. auto industry has been that until recently there was only one producer in the United States. However, there is far more interest today than there was several years ago. Successful applications of magnesium in the automotive industry will depend to some extent on the availability of the metal and on the continuing development of expertise in handling the metal on the part of auto makers and die-casting suppliers. With improvements in primary production processes and the development of the hot chamber and associated fluxless melting technology, it promises to be a competitive die-casting metal in the future.

TABLE 7.2.1

ENERGY REQUIREMENTS TO PRODUCE ZINC AND OTHER COMMODITIES

COMMODITY	ENERGY REQUIREMENTS kwh/tonne	kwh/lb.
Zinc	6,614	3.0
Aluminum	22,046 27,557	10.0 – 12.5
Copper	8,818 11,023	4.0 – 5.0
Lead	3,307	1.5
Plastics	27,557	12.5

Source: M.R. Davidson, "Zinc, A versatile Strategic World Commodity", Automotive Engineering Congress and Exposition, Feb., 1975.

TABLE 7.2.2

ENERGY COST IN TERMS OF COMMODITY PRICE

COMMODITY	FUEL REQUIREMENT* MILLION BTU/tonne METAL	CURRENT METAL PRICES $/lb.	FUEL COST AS % OF METAL PRICE
Zinc	66.14	0.41	7.3%
Aluminum	308	0.41	34.2%
Copper	88	0.63	6.0%
Nickel (Sulphide Ore)	220	2.20	4.5%
Nickel (lateritic Ore)	661	2.18	13.6%
Lead	33	0.20	10.0%
Steel	30	0.125	16.0%

* includes electrical energy @ 10,600 BTU/kwh

Source: J.C. Agarwal, J.R. Sinek, "The Energystics of Metal Production", Energy Use and Conservation in the Metals Industry Processing of a symposium at the 104th AIME Annual Meeting, Feb., 1975.

7.3 Brass

Zinc comprises 5% to 40% of brass, by weight, the remainder being copper. Brass products account for major zinc consumption in Europe, where the introduction of substitute materials has been slower than in the United States. Since copper prices have generally been two to three times that of zinc, price-sensitive substitutions between brass and other materials such as aluminum, are much more dependent on copper prices than on zinc prices.

Appendix "A"

Classification of Mineral Reserves and Resources*

*Source: Robertson, James A.
1975: Mineral Deposit Studies, Mineral Potential Evaluation, and Regional Planning in Ontario; Ontario Div. Mines, MP61, 42p.

For the purpose of the classification, a **Resource** is defined as "a concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible". A broader term is **Resource Base** which constitutes all the commodity in question present in the earth's crust.

Resources are divided into three groups, discovered resources, expected additional resources and speculative resources. The relationships between these groups are shown in the Ontario Mineral Resources Classification Diagram, and are discussed below:

a) **Discovered Resources**

Discovered resources are specific bodies of mineral bearing material whose location, quality and quantity are known from geological evidence supported by engineering measurements. These resources are composed of proven and probable reserves plus conditional resources.

i) *Proven Ore Reserves*

Proven ore is that material for which tonnage is computed from dimensions revealed in outcrops or trenches or underground workings and/or drill holes and for which the grade is computed from the results of adequate sampling. The sites for inspection, sampling and measurement are so spaced and the geological character so well defined that the size, shape, and mineral content are established. The computed tonnage and grade are judged to be accurate within limits which must be stated. It must be stated whether the tonnage and grade of "proven" ore is in situ or extractable, with dilution factors shown, and reasons for the use of these dilution factors clearly explained.

The above definition is that approved for use in submissions to the Ontario Securities Commission. Calculated tonnages and grades are required to be accurate to within twenty percent. Proven ore may be taken as being the same as "measured ore" as the term is defined by the United States Bureau of Mines. Some jurisdictions include the phrase "legally extractable at the time of the study". This would exclude measured mineralization in, for example, a national or provincial park.

ii) *Probable Ore Reserves*

Probable ore is that material for which tonnage and grade are computed partly from specific measurements, samples, or production data, and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to outline the material completely or to establish its grade throughout.

Probable ore may be taken as being the same as "indicated ore" as defined by the United States Bureau of Mines.

For purposes such as feasibility studies, summation of tons and grade of proven and probable ore reserves may be acceptable if it is stated that they are combined.

iii) *Conditional Resources – Para Marginal*

Para marginal conditional resources are discovered resources not at present economically mineable but which are expected to become so within the next 25 years with a likelihood of more than 50%.

The time span and probability factory may vary from case to case and must be stated. It must be noted that the definition refers to deposits which will become economically mineable. This does not necessarily mean that they will actually be mined with the stated time span.

iv) **Conditional Resources – Sub Marginal**

Sub-marginal conditional resources are discovered resources not at present economically mineable but which may become so within the next 25 years. The likelihood is, however, less than 50% although more than 10%.

b) **Expected Additional Resources**

Expected additional resources are undiscovered materials that may be reasonably expected to exist in known mining districts under known geological conditions.

Exploration that confirms the existence of expected additional resources, and reveals quantity and quality, will permit their reclassification as proven or probable reserves or conditional resources.

Expected additional resources may be classified into economic, para-marginal, and sub-marginal categories in the same way as discovered resources.

A special case of economic expected additional resources are **Possible Reserves** which are defined as follows:

"Possible ore is that material for which quantitative estimates are based largely on a broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there are reasonable geological indications; these indications may include comparisons with deposits of similar type. Bodies that are completely concealed may be included if there is specific evidence of their presence".

Possible ore is similar to "inferred ore" as defined by the U.S. Bureau of Mines although, to most geologists, "inferred" is a considerably broader term than "possible".

The inclusion of possible ore in ore reserves for the purposes of cost and feasibility studies is not acceptable.

c) **Speculative Resources**

Speculative resources are undiscovered materials that may occur in known types of deposit in a favourable geological setting **where no discoveries have yet been made** or in as yet unknown types of deposit that remain to be recognized.

Exploration that confirms the existence of speculative resources and reveals quantity and quality will permit their reclassification as proven or probable reserves or conditional resources.

Speculative resources may be classified into economic, para-marginal, and sub-marginal categories in the same way as discovered resources. This exercise has, however, limited practical value.

ONTARIO MINERAL RESOURCE CLASSIFICATION

<table>
<tr><td colspan="4" rowspan="5"></td><td colspan="4">INCREASING CERTAINTY OF EXISTENCE</td></tr>
<tr><td colspan="2">DISCOVERED RESOURCES</td><td>PARTLY DISCOVERED</td><td>UNDISCOVERED</td></tr>
<tr><td colspan="2">Known Deposits</td><td>Expected Additional
(In Known Areas)</td><td>Speculative
(In Unknown Areas)</td></tr>
<tr><td>Proven</td><td>Probable</td><td>Possible</td><td rowspan="2"></td></tr>
<tr><td>Measured</td><td>Indicated</td><td>Inferred</td></tr>
<tr><td rowspan="3">INCREASING LIKELIHOOD OF BECOMING ECONOMICALLY MINEABLE WITHIN 25 YEARS</td><td>100%</td><td colspan="2">Economic (now)</td><td colspan="2">1 A
RESERVES</td><td>2A</td><td>3A</td></tr>
<tr><td>50%</td><td rowspan="2">Sub-economic</td><td>Para-marginal</td><td colspan="2">IB
CONDITIONAL
RESOURCES</td><td>2B</td><td>3B</td></tr>
<tr><td>10%</td><td>Sub-marginal</td><td colspan="2">IC
Conditional
Resources</td><td>2C</td><td>3C</td></tr>
</table>

Appendix "B" Basic Properties

Basic Properties

General Properties

Symbol	Zn
Atomic Number	30
Atomic Weight	65.37
Valence	2.
Crystal Structure	Close-packed Hexagonal
Density at 20°C. (68°F.)	
Grams per Cubic Centimeter	7.13
Pounds per Cubic Inch	0.258
Specific Volume (Cubic Centimeters per Gram) 20°C. (68°F.)	0.140

Zinc is blue-white in color, but in the rolled form appears gray-white.

Thermal Properties

Melting Point	419.46°C(787°F.)

Zinc of commercial purity, such as Special High Grade, High Grade, and Prime Western usually melts at a slightly lower temperature.

Boiling Point	906°C.(1663°F.)
Latent Heat of Fusion	24.09 Calories per Gram
Latent Heat of Vaporization	425.6 Calories per Gram
Heat of Combustion	85,156 Calories per Gram
Specific Heat	.0915 Calories per Gram
Coefficient of Linear Thermal Expansion	39.7×10^{-6} per °C.

(Special High Grade in Temperature Range 0°C. –250°C.)

Percent Thermal Conductivity (Silver = 100%) 20°C.	27.7
Thermal Conductivity	.27 cal/sec/sq.cm/°C/cm

(Special High Grade at Room Temperature)

Electrical Properties

Resistivity (microhm-cm)	
(Solid Zinc-Special High Grade) 20°C. (68°F.)	5.916
(Liquid Zinc-at melting point)	35.3
Per cent Electrical Conductivity (Copper = 100%) 20°C.	28.5
Temperature Coefficient (in range 0°-100°C.)	+.00419 microhm/cm/°C.

Electrochemical Properties

Electrochemical Equivalent	
mg/coulomb	0.3388
grams/amp hour	1.2194
Solution Potential (Electrode Reduction Potential)	0.7618 volt
Hydrogen Overvoltage	0.75 volt
On a reasonably smooth surface at 10 amps/sq. ft.	

Zinc becomes super conductive at 0.84±0.05°K

Appendix "C"

Slab Zinc Specifications in the U.S.

SLAB ZINC SPECIFICATIONS IN THE U.S.

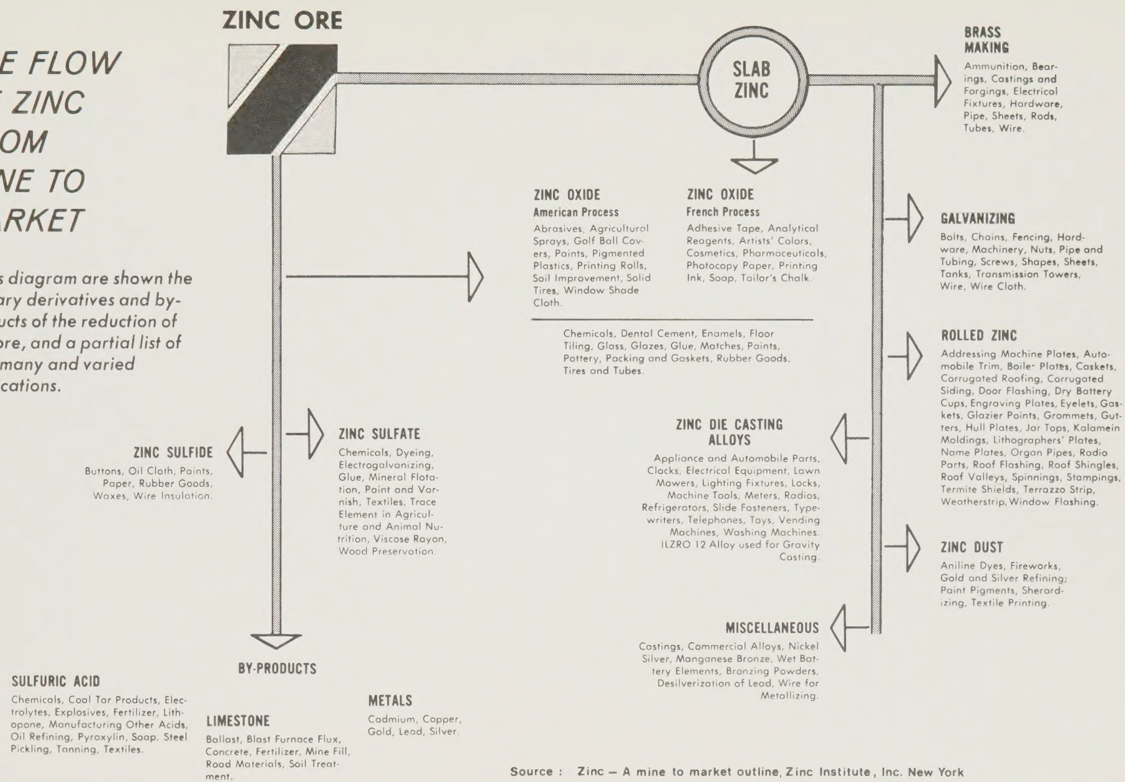
GRADE	Minimum Zinc Content	← Maximum →		
		Lead	Iron	Cadmium
	%	%	%	%
Prime Western	98.0	1.6	0.05	0.5
High Grade	99.90	0.07	0.02	0.03
Special High Grade	99.990	0.003	0.003	0.003
Brass Special	99.0	0.6	0.03	0.5
Intermediate	99.5	0.20	0.03	0.40

Appendix "D"

The flow of Zinc from Mine to Market

THE FLOW OF ZINC FROM MINE TO MARKET

In this diagram are shown the primary derivatives and by-products of the reduction of zinc ore, and a partial list of their many and varied applications.



Source : Zinc – A mine to market outline, Zinc Institute, Inc. New York

Ontario Ministry of Natural Resources

Mineral Resources Branch

Mineral Policy Background Papers

No. 1: G. Anders, W. P. Gramm, S.C. Maurice: **The Impact of Taxation and Environmental Controls on the Ontario Mining Industry – A Pilot Study.** 1975 $3.00

No. 2: Staff, Metallic Minerals Section: **Towards an Iron Ore Policy for the Province of Ontario.** 1975. $2.00 (out of print)

No. 3: K.S. Rachamalla, D.H. Bell: **Towards a Zinc Policy for the Province of Ontario.** 1976. $12.00
5509 (11/76)

Publications of the Ontario Division of Mines
and price list
are obtainable through the
Mines Publications Office, Ontario Ministry of Natural Resources
Parliament Buildings, Queen's Park, Toronto, Ontario
and

The Ontario Government Bookstore
880 Bay Street, Toronto, Ontario.

Orders for publications should be accompanied by cheque,
or money order, payable to Treasurer of Ontario.